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SPORTING GUNS

AND

GUNPOWDERS:

COMPRISING

A SELECTION FROM REPORTS OF EXPERIMENTS,

AND OTHER ARTICLES,

PUBLISHED IN THE "FIELD" NEWSPAPER,

RELATIVE TO FIRE ARMS AND EXPLOSIVES.

COMPILED BY THE PRESENT EDITOR OF THE "FIELD."

PART I.

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HORACE COX,

WINDSOR HOUSE, BREAM'S BUILDINGS, CHANCERY LANE, E.C.

1897.

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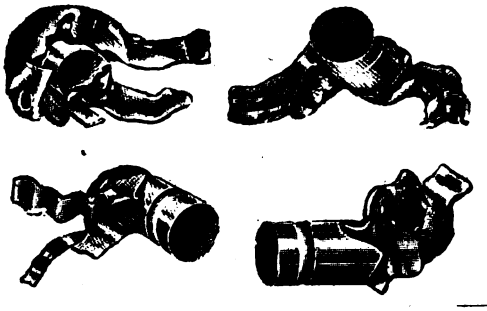

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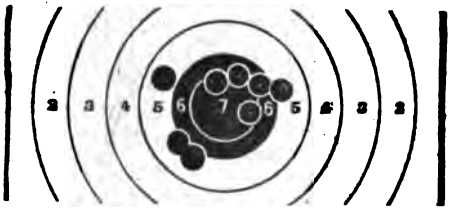

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[redacted] BY THE PRESENT EDITOR OF "THE FIELD."

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PREFACE.

READERS of the *Field* have frequently suggested that a republication should be made of the reports of trials and experiments with sporting guns and gunpowders which have been recorded in the columns of that newspaper. As a new schedule amending the Gun Barrels Proof Act of 1868 has recently been framed by the authorities of the London and Birmingham Proof Boards, and has received the official sanction of Her Majesty's Principal Secretary of State for the War Department, the issue of the amended rules of proof may provide a fitting opportunity for publishing therewith a selection from those articles which have more or less connection with the proof of guns. Numerous experiments have been carried out, from time to time, for the purpose of testing the strength of gunbarrels and the explosive forces of various old and new gunpowders under different conditions of dryness and moisture; and although some of the instruments hereafter described and depicted may not be up to date in comparison with other methods which are now more generally adopted, the information given may possibly enable the general or uninstructed reader to obtain a clearer perception of cause and effect than the merely arithmetical records obtained from experiments with apparatus of a strictly scientific character. The particulars stated with regard to the cruder instruments may also have the effect of making more comprehensible some of the details supplied relative to investigations carried out with modern appliances. And, in like manner as crusher-gauges with their small solid lead cylinders have supplanted the leaden cartridge chambers as indicators of explosive power, so have paper pads and the force-gauge been surpassed by electric chronographs as indicators of the penetration or striking force of shot.

As the articles now republished may possibly be hereafter found useful as *mémoires pour servir* in the history of gunnery, and some of the reports have here been greatly condensed, mention is made of the dates, pages, &c., of the issues of the *Field* in which the original articles were published. Many gentlemen possess bound volumes of that journal; and copies are also to be seen in the British Museum and other public libraries; so that the addition of these particulars may spare investigators some trouble should they wish to search for further details.

It is due to the memory of the late Mr. John Henry Walsh, F.R.C.S.* (who was editor in chief of the *Field* for the thirty years from the end of 1857 to the beginning of 1888), to state that the initiative of these experiments was entirely due to him, and that he designed various kinds of apparatus which have been used in carrying them out. For some months before Mr. Walsh assumed the reins of office a fierce controversy had been carried on in the correspondence columns of the *Field* with respect to the relative merits of muzzle-loaders and breechloaders, as guns made on the Lefaucheux or French crutch system had been gradually making their way among English sportsmen since their appearance in the Great International Exhibition of 1851, in Hyde Park. For some short time before Mr. Walsh was appointed editor, he had been an occasional contributor to the *Field*; and one of his first acts after taking the chief command was to draw up a set of rules and conditions for a public contest, which should serve to demonstrate the respective merits of the old and the new varieties of guns. For this trial, held in 1858, Mr. Walsh's first machine for the registration of recoil was constructed, though it was not much used until the second trial of breechloaders and muzzle-loaders in 1859. In this second trial, the square pads, of forty or more sheets of thick brown paper, were also introduced, for the purpose of recording the

* Mr. Walsh was better known to the general public by his *nom de plume* of "Stonehenge." Before he became editor of the *Field* he had published (in 1856) his volume on "British Rural Sports," which has since passed through seventeen editions. In this work he gave particulars of the breechloaders then coming into vogue, and inserted fuller details in his book on "The Shot Gun and Sporting Rifle" (published in 1859). Vol. I. of "The Modern Sportsman's Gun and Rifle" (which appeared in 1882) was devoted to game and wildfowl guns; and Vol. II. (published in 1884) treated of sporting and match rifles, together with revolvers. His other works include "The Horse in the Stable nd the Field" (12th edit., 1887); "Dogs of the British Islands" (5th edit., 1886); "The Dog in Health and Disease," and "The Greyhound: A Treatise on Breeding and Training of Greyhounds for Public Coursing." He was also the author of books on domestic economy and domestic medicine, and e inventor of various contrivances in connection with guns, tricycles, &c.

penetration of the shot; and these pads continued to be used for nearly twenty years, up to the trial of cylinder and choke-bore guns with nitro and black powders in 1878. In 1879, however, the paper pads gave way to Mr. Walsh's force-gauge, with which the trial of 12, 16, and 20-bore guns was carried out. In 1884 he had hollow leaden cylinders made to serve as the artificial breech end of a gunbarrel, whereby to test the explosive force of gunpowders, and ascertain what effects were produced by undue drying of the powders. Since Mr. Walsh's death, other instruments and improvements upon his original constructions have been introduced; and some of the results of experiments made with the various kinds of apparatus are given in subsequent pages, together with occasional remarks tending to show the bearing of one set of experiments upon another series.

It may perhaps be as well to state, too, that the compiler of these pages had been Mr. Walsh's assistant during the full period of his editorship, and had had more or less to do with the whole of the gun trials and with many of the other experiments. For many of the statistics here published he is responsible, as the editor in chief had little personal liking for arithmetical computations; and the compiler is likewise responsible for the condensation of reports of the older gun trials into comparatively narrow dimensions. Since Mr. Walsh's death (and occasionally before), various unsigned articles which are reprinted in these pages have been written by the compiler; but the practical experiments carried out during the last seven or eight years have been almost entirely the work of another member of the *Field* staff, Mr. Horatio F. Phillips, who has made most important improvements in the apparatus in various respects—especially in the recoil-gauge (depicted on page 122), which is believed to be the most accurate instrument for this purpose that has ever been constructed. In reprinting articles which were originally unsigned, it has been thought desirable to afford some means of identification, and therefore initials are appended. Thus, where experiments were carried out by Mr. Walsh, and his reports have been condensed in this book, the initials W.—T. are given to indicate the original author and the present editor; and, in like manner, where more recent experiments have been carried out by Mr. Phillips, and the present editor has written the articles thereon, they bear the initials P.—T. Likewise, where Mr. Griffith, or other experimenters, have supplied facts, but are not answerable for the comments on them, the initials appended will give intimation of the division of responsibility.

As regards the signed articles, their merits must speak for themselves; and the compiler thanks most warmly the various gentlemen who have added so much information to the general store of knowledge about sporting guns and gunpowders.

The present pamphlet is but a section of the proposed volume, which it is thought best to issue in parts; and further records of experiments can thus be included from time to time as the work progresses. To make the information more readily accessible, it is proposed to publish an index with every part, and to include in each section the particulars of the contents given in its predecessors, so as to avoid the trouble of looking over several indexes. In this way it is hoped that various contributions which have found a resting-place in the columns of a weekly newspaper may be rescued from the limbo of forgotten things, and made to do fresh service in the hands of students of the science of gunnery.

FREDERICK TOMS, Editor.

Field Office, Bream's Buildings, London, E.C.
December, 1896.

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SPORTING GUNS AND GUNPOWDERS.

THE NEW GUN PROOF RULES.

(*Field*, March 28, 1896; vol. 87, p. 455.)

THE SHOOTING SEASON having waxed and waned two months ago, it is not now possible to stimulate interest in the proof question by reference to accidents which happened yesterday. The recollection, however, of shattered guns, and possibly of shattered hands, will doubtless, in at least many cases, serve to keep green in the memory the importance of the Proof Boards running abreast with the times, and altering their conditions of test to meet the change which has come over the manufacture of explosives. The old rules, as our readers may remember, were very crude, and these were replaced in 1887 by a more modern code, which, while showing an improvement on that previously in force, nevertheless left a good deal to be desired. The regulations formulated nine years ago have now in their turn been supplanted by others which, in accordance with the provisions of the Gun Barrel Proof Act, 1868, have been put forth by the Gunmakers' Company and the Guardians of the Birmingham Proof House with the consent of Lord Lansdowne, the Principal Secretary of State for War. Before proceeding to discuss the new rules, shooting men may be reminded that rule 10 of the 1887 code was new and was very properly regarded as a step in advance. It provided that barrels for arms of any class should, at the written request of any person sending the same for definitive proof, be proved with any powder the sender might specify. The rule, too, was so far prospective that any powder thereafter to be invented could be selected by the sender of the barrels. It might have been expected, even if gunmakers as a body might shrink from this test, that those at any rate who turn out arms of high class would not have been slow to avail themselves of something which might almost be regarded in the light of an advertisement. Yet it was pointed out in our columns just five years ago that, out of 40,827 choke-bore guns, no more than twenty-eight were proved at Birmingham with nitro powders. In the month of November, 1893, the Proof Boards issued a notice drawing attention to the fact that, for sundry reasons, risks were run by those who used nitro powders in guns which had been proved with black powder only, and urging that the proof should be made with the explosive it was intended to use with the gun. Nor has there been since that time any great desire to make the most of the facilities afforded by the Proof Boards. In our last issue we gave a statement of the revenue account of the Gun Barrel Proof House of Birmingham, from which it appeared that no more than a hundred and seven breechloading guns were submitted to the optional proof for nitro explosives out of a total of about fifty thousand. The cost of this test is 1s. 6d., a comparatively large sum, perhaps, when compared with the few pence charged for some other proofs, but surely worth paying, even though the proof meant nothing more than that the gun was presumably safe for use with the one nitro powder with which it was tested.

Of the fresh rules, the tenth is new and is of an important nature, though it scarcely goes far enough: it does not take it out of the power of the senders of guns to make the new rule a dead letter. It deals with arms included in classes four, six, and eight, that is to say, speaking generally, with shot guns of the cylinder and choke-bore patterns. "Barrels for arms of the fourth, sixth, and eighth classes," says the new rule 10, "in which nitro powders are intended to be used, shall be so declared in writing by the sender, and shall receive a supplementary proof with the powder now known as Curtis and Harvey's 'No. T.S. 2' powder (or a similar powder in all respects), in addition to the ordinary Definitive Proof." When we read that the guns included in the three above-mentioned classes in which nitro powders are intended to be used *shall* be so declared in writing, and *shall* be subject to a supplementary proof of finer grain powder, there would at first sight seem to be balm in Gilead in the shape of a compulsory supplementary proof. On reading the rule more carefully, however, it will be seen that this supplementary proof which we have wished for, and which we have long advocated, is only optional after all. There must be first, on the part of the person who sends the gun to be proved, an *animus probandi*. He must first state in writing that the gun he sends is intended to be used with nitro powders. As it is, in almost every instance, the gunmaker, and not the purchaser, who sends the gun to one or other of the proof houses, the written declaration may in every instance be dispensed with; for it is perfectly clear that the gunmaker does not "intend" his gun to be used with any particular kind of explosive; it is the buyer who does the intending. The gunmaker sells the gun, leaving it to his customer to load the cartridges with what he likes —sawdust, if it so pleases him. Since, therefore, as we construe the new rule, it is entirely at the gunmaker's option whether the written declaration be made, it follows as a matter of course that the supplementary proof is also optional. If, however, according to our view, the written declaration be made that the gun in question is intended to be used with nitro powders, then the supplementary proof becomes compulsory, and on the weapon passing the ordeal it will be specially marked, as provided in the rules. Bearing in mind, then, that gunmakers, as a body, have hitherto fought shy of submitting their work to the voluntary tests, there is not the

slightest ground for hoping or expecting that many guns will be declared in writing to be intended for use with nitro powders; so that the new rule is likely to become practically a dead letter. Indeed, it hardly appears worth taking the trouble to obtain Lord Lansdowne's assent to a regulation which will be no more taken advantage of than was the offer to prove guns with nitro powders contained in the old tenth rule. At the same time, while we readily admit that the gunmaker will be perfectly justified, according to the wording of the rule, in declining to make the written declaration which is the condition precedent to the supplementary proof, there can be no possible doubt that 99 sporting guns out of every 100, nowadays, are to all intents and purposes intended to be used with nitro powders; and, that being so, it is, from our point of view, a pity that the Proof Boards did not take the intention as a matter of course, and make the supplementary proof compulsory. There is just a bare possibility of one little question arising under this new rule. If someone ordered a gun, and expressly stated that he was going to use some particular nitro-compound in it, that particular gun would at least be one "in which nitro powders are intended to be used," so the written declaration as to intent ought to be made; but no penalty is provided for not making it, so all the "shalls" in the rule count for nothing.

There is more, however, in the power of the purchaser to give effect to the rule than might at first be supposed. When a man buys a horse, he buys it as a rule upon the condition that it passes the veterinary surgeon. Let shooting men take a leaf out of the book of riding men, and buy their guns subject to their passing the supplementary proof with the fine-grain black powder, and let them reject any gun which does not bear the special proof-mark "Nitro Proof oz. maximum," as described in section 46 of the rules given in another page. Then they will know for what the gun has been proved; and if they use larger charges of shot (which are very likely to intensify the pressure given by nitro-compounds) they will do so at their own risk.

In the event of a gun being subject to this supplementary proof, a 12-bore would be tested with 4½drs. of No. 2 powder and 1⅛oz. of shot, while a "12 extra" (such as would be used for pigeon shooting) would have 4¼drs. of powder and 1⅛oz. of shot. The old rule 10 is now, with some modification, rule 11; that is to say, notwithstanding the new rule 10, any barrels may, on request, be proved with any powder the sender likes to select; but the new wording provides that the quantity of the chosen powder shall be such as to give a strain of not less than 80 per cent., and not more than 100 per cent., over that of the Service charges. The conditions under which rifles are henceforth to be proved differ in sundry particulars from those of the 1887 rules. The first part of the old rule 16 stands as part of new rule 17, as will be seen on reference to the subsequent columns, the new wording being printed in italics. Those interested in rifles will not fail to notice that the ·303 rifle is the subject of special attention, it being laid down that an arm of that diameter, taking the Service cartridge, shall be definitively proved with 45grs. of Rifleite (or a similar powder in all respects), and with a lead plug 287grs. in weight, while, in the case of rifles of greater or lesser diameter than ·303, the written declaration again crops up. It will further be noticed that duck guns are now for the first time specially provided for, as shot guns having barrels not less than 5½ft. in length shall be proved with Curtis and Harvey's "Colonel Hawker's Duck Gun Powder," the amount of powder being twice that of the declared Service charge, with one and one-third the weight of shot of the declared Service charge; but these guns may also be proved with nitro powders.

These are the main points in which the new rules differ from the old, and we are glad that the companies of London and Birmingham are not unmindful of the duty they have to perform; but we do not conceal our regret that the supplementary proof is still optional. As we stated a fortnight ago, we hold to the opinion that a charge of fine grain powder should be the last test for the purpose of proving the breech. The number of explosives is ever on the increase, and their powers are so diverse that, in the interest of the man who handles a gun, both the slow and the quick burning powders are necessary before the proof tests can be regarded as complete.

NEW RULES FOR THE PROOF OF GUNS.

THE *LONDON GAZETTE* of March 24, 1896, contains the new proof rules, which, after the expiration of three months' notice, are to be substituted for those hitherto in force. The rules and regulations have been made by the Gunmakers' Company (London) and the Guardians of the Birmingham Proof House, under authority of the Gun Barrel Proof Act of 1868, and received the approval of the Marquis of Lansdowne, the Secretary of State for War, on March 10. We have made some general remarks on the subject in a leading article given on a previous page, but, as the rules are voluminous, and many of our readers are probably not familiar with those already in existence, we indicate the most material changes in the rules by printing the altered sections in italic; as the present schedule is to be substituted for Schedule B in the Gun Barrel Proof Act of 1868:

RULES AND REGULATIONS made in the month of February, 1896, by the Gunmakers' Company and the Guardians of the Birmingham Proof House, under Authority of the Gun Barrel Proof Act, 1868.

WHEREAS in and by section 117 of the Gun Barrel Proof Act, 1868, the Gunmakers' Company and the Guardians of the Birmingham Proof House in such Act, and hereinafter referred to as "the Two Companies," are empowered, should they deem the proof or the rules, regulations, and scales stated in Schedule "B" to the said Act annexed, or any of them respectively, insufficient or inapplicable or unsuitable, on application to and with the approval of Her Majesty's Principal Secretary of State for the War Department, to repeal or alter all or any of the rules and regulations, and all or any part of the scales respectively from time to time in force under the said Act for the proof of small arms, or of any classes of small arms, and to make, repeal, and alter any new rules and regulations, and any new scales in that behalf.

And whereas the rules, regulations, and scales now in force under the said Act are the rules and regulations made in the month of December, 1887, and which were approved by the Right Honourable Edward Stanhope, Her Majesty's then Principal Secretary of State for the War Department, on the 28th December, 1887. And whereas since the approval of the last-mentioned rules and regulations, certain improvements and alterations have been made in the manufacture of explosives for use in small arms, in consequence of which alterations are necessary in the rules, regulations, and scales of proof.

Now, therefore, the Two Companies with the approval of the Most Honourable the Marquis of Lansdowne, K.G., Her Majesty's Principal Secretary of State for the War Department, do hereby repeal the said rules and regulations and scales made in the month of December, 1887, and in lieu thereof do make the following rules, regulations, and scales, that is to say:—

SCHEDULE B.

CLASSIFICATION OF SMALL ARMS.

1. *First Class.*—Comprising single-barrelled muzzle-loading military arms of smooth bore.

2. *Second Class.*—Comprising double-barrelled military arms of smooth bore, and single muzzle-loading rifled arms of every description, except arms of the Seventh and Eighth Classes.

3. *Third Class.*—Comprising every description of single-barrelled Birding, "Danish," "Dutch," "Carolina," and "Spanish" arms, not being breech-loaders.

4. *Fourth Class.*—Comprising every description of double-barrelled fowling-pieces and rifles, and breech-loading arms of every description and system, not being of the Fifth, Sixth, Seventh, or Eighth Classes.

5. *Fifth Class.*—Comprising revolving small arms of every description and system.

Sixth Class.—Comprising all arms, except those of the Eighth Class, having one or more barrels choke-bored, *i.e.*, barrels wherof the diameter of the bore at the muzzle is less than the diameter of the bore at some point behind the muzzle other than the chamber or recess which contains the charge.

7. *Seventh Class.*—Comprising Express rifles, *i.e.*, rifles intended to be fired with a larger charge of powder than ordinary rifles, and which must be so declared in writing when sent for Definitive Proof.

8. *Eighth Class.*—Comprising choke-bored barrels having all or a portion of the smaller diameter of their bore rifled.

RULE OF PROOF.

9. *The Gunpowder* used shall be of strength equal to Waltham Abbey "R.F.G. 2," but of a Mixed Grain, to pass through Sieves of No. 27 Wire Gauge, varying between 17 and 36 meshes to a lineal inch, and no change shall be made therein without the consent of Her Majesty's Secretary of State for War.

10. *Barrels for arms of the Fourth, Sixth, and Eighth Classes, in which nitro powders are intended to be used, shall be so declared in writing by the sender, and shall receive a supplementary proof with the powder now known as Curtis and Harvey's No.* "T S 2." *Powder (or a similar powder in all respects), in addition to the ordinary Definitive Proof, and shall be specially marked as hereinafter provided. Scale No. 5 in the Schedule to these rules sets forth the said supplementary proofs applicable to barrels of various bores. The two Companies are empowered to frame scales of these supplementary proofs for barrels of any other bores. In case barrels sent for proof for the use of nitro powders are intended by the senders to shoot charges of powder or shot greater than the ordinary service charges of the respective bores set forth in Scale 6, in the said Schedule, then the quantities of powder and shot so intended to be used shall be declared in writing, and a proof charge proportionate thereto shall be used.*

11. *Barrels for arms of any class, shall, at the request in writing of any person sending the same for Definitive Proof, be proved with "Schultze," "E.C," or any particular description of gunpowder which may be specified, after and in addition to the ordinary Definitive Proof. The service charges of such powders shall be determined by the two Proof Companies respectively from time to time, and the quantities of the said powders to be used in proof shall be such as the two Companies shall decide to give a stress not less than 80 per cent. nor more than 100 per cent. over that of the service charges in Scale No. 6 to these rules. The service charges of such powder and shot shall be marked on the barrels. If any new powders shall come into use, or the existing powders be increased in strength, the same regulations shall apply thereto.*

12. *The Bullets* used shall be of lead, of the specific gravity 11·352, and of the size and weight prescribed by the respective Scales for Proof. The bullets, except those used for rifled arms, shall be spherical, cylindrical, or conical in shape, and for rifled arms they shall be cylindrical and flat-ended. For arms of the Eighth Class they shall be conical, and of a diameter not more than ·005 of an inch less than the muzzle diameter of the barrel.

13. For the Definitive Proof of all shot barrels, except for arms of the Eighth Class, shot shall be used instead of bullets.

14. *The Shot* used shall be of lead, and of the size and description known in the gun trade as "Soft Shot," size No. 6.

15. *The Wads* to be used shall be of solid felt, and shall not exceed in thickness one diameter of the bore, one wad to be placed over the powder and another over the bullet.

16. The charges of powder and lead for Provisional Proof of all arms shall be according to such scale to these rules as may be applicable thereto respectively. The charges for Definitive Proof, except for arms comprised in Rule 17, shall be according to No. 3 scale to these rules.

17. Barrels for rifled arms of the Second Class, and for arms of the Fourth, Sixth, and Seventh Classes, shall be definitively proved with double the quantity of powder and one and one-third the weight of lead of the service charges set forth in the respective scales to these rules. Barrels for arms of the Eighth Class shall be definitively proved with double the quantity of powder and one and one-half the weight of lead of such service charges. *Barrels for rifled arms of ·303 diameter, taking a nitro cartridge of the form and dimensions now employed in the British Service Magazine Rifle, should be proved definitively with 45grs. of the powder known as "Rifleite" (or a similar powder in all respects), and with a lead plug 287grs. in weight, covered with greased paper. Barrels for rifles of larger or smaller diameter than ·303, and in which nitro powder, and a bullet four or more calibres in length, are intended to be used, shall be so declared in writing by the sender, and shall be proved with such a proportionate amount of Rifleite and lead as that the excess of proof stress shall be in the same ratio as that for the ·303 rifle aforesaid. Nothing in this rule shall prevent the sender of a rifle barrel, on request in writing, from having it definitively proved with a greater charge than is provided in this rule, at a proportionate increase of price—nevertheless it shall be marked in the ordinary way.*

18. For all military arms manufactured for the British Government, the scales of proof shall be the same as used by Her Majesty's War Department from time to time.

19. Barrels for breechloading arms of the Fourth Class, and for arms of the Sixth, Seventh, and Eighth Classes, shall be Proved Provisionally and Definitively. Barrels for arms of the Second Class, and single breech-loading arms and muzzle-loading arms of the Fourth Class, shall be Proved Provisionally and Definitively, or on the request in writing of the person or persons sending the barrels for proof shall be proved once only, in which case such barrels shall be sent in the state for definitive proof, but shall be proved according to the scale for provisional proof, and shall be marked with a special mark denoting that such barrels have been proved in the definitive state according to the scale for provisional proof. Barrels for arms of the First and Third Classes shall be proved once definitively; but the scale used for proving such barrels for arms of the Third Class as have the diameter of the bore in every part 1¼in. or upwards shall be the provisional scale.

20. Nevertheless, it shall be sufficient from time to time to prove all breechloading military barrels in the same manner as breechloading military barrels made for the use of Her Majesty's Forces, and with the same weight of gunpowder as is now used, or from time to time shall hereafter be used, in the proof of similar barrels at the Government Factories.

21. As to any military barrel made for the use of Her Majesty's Forces, or for the late Honourable East India Company, which has ceased to belong to Her Majesty, but which bears in addition to a Proof Mark authorised by Her Majesty's War Department, the letter "O" struck (prior to such cesser) over or upon the broad arrow or some part thereof by the said War Department, it shall, if it be a rifled barrel, be proved with Definitive Proof, or if it be a smooth-bore barrel with half the charge of powder, but with the same weight of bullet which would be applicable to the proof thereof if such barrel were an unproved barrel under the said Act and these Rules, and after either such proof, such barrel shall be marked as Proved Definitively; and as to any military barrel made for the use of Her Majesty's Forces, or for the late Honourable East India Company, which has ceased to belong to Her Majesty, and which does not bear in addition to a Proof Mark authorised by Her Majesty's War Department the letter "O," or the letter "S" struck (prior to such cesser) over or upon the broad arrow or some part thereof by that Department, it shall (whether it shall or shall not bear a Proof Mark authorised by that Department) be liable to proof as an unproved barrel according to its classification under the said Act and these Rules.

22. All breech-loading shot barrels of 10-bore or less, having chambers of 3in. or longer, shall be so declared in writing by the sender, and be proved with one-sixth more powder than the ordinary Definitive Proof Charge.

23. Barrels for arms of the Fourth Class, of larger gauge than four, and for which no service charge is laid down in the Scale, shall have the service charge declared in writing by the person or persons sending the same for proof, and be proved with a charge bearing the same proportion to such service charge as defined by Rule 17. *Shot guns, having barrels not less than 5½ft. long, in which a coarse powder is to be used, shall have the intended service charge declared in writing by the sender, and they shall be proved with the powder known as Curtis and Harvey's "Col. Hawker's Duck Gunpowder" (or a powder similar in all respects), and shall be proved with double the amount of powder, and one and one-third the weight of shot of the declared service charge, and the said service charge shall be marked on the barrel. In case a nitro powder is to be used, the provisions in Rules 10 and 11 shall apply hereto.*

24. A barrel of any description to which the classification or scales of proof are, in the judgment of either of the two Companies, inapplicable or unsuitable, shall be proved with such a bullet or charge of shot as shall be applicable to the dimensions of the bore of such barrel, and with such a charge of powder as shall give a stress not less than is provided in Rule 11, or in case the barrel shall not be capable of holding such Proof Charge, with as much powder as the barrel is capable of holding.

25. The several powders used in proof, shall at all times be open to the inspection of any officer authorised for the purpose by the Secretary of State for War who may take samples for examination, or trial of the same, without notice.

CONDITIONS PRECEDENT TO PROOF.

26. Barrels for arms of the First Class shall not be qualified for proof until they shall be in a fit and proper state for setting up, and the thread of the screws sound and full.

27. Barrels for arms of the Third Class shall not be qualified for proof until they shall be bored and ground, and in a fit and proper state for setting up, with the squares set off, looped, and the proper breeches in, and all the threads of the screws sound and full; and all barrels for percussioned arms shall be percussioned, and shall be proved with the proper nipples in.

28. Barrels for arms of the Second, Fourth, Sixth, Seventh, and Eighth Classes:

For Provisional Proof.—If of plain metal, shall be bored and ground, having plugs attached, with touch-holes drilled in the plugs of a diameter not exceeding one-sixteenth of an inch. Notches in the plugs instead of drilled touch-holes shall disqualify for proof. If of twisted metal they shall be fine-bored and struck up with proving plugs attached and touch-holes drilled as in the case of plain metal barrels.

For Definitive Proof.—The barrels, whether of plain or twisted metal, shall be smoothed in the finished state, with the breeches and barrels in the percussioned state, huts filed up, inside of barrels shall be cleaned, the top and bottom ribs of double barrels shall be fairly struck up, pipes, loops, and stoppers on, the proper breeches and nipples in, the thread of the screws sound and full, and all rifle barrels shall be rifled.

29. Barrels for breech-loading arms shall receive the final proof after the breech-loading action is attached complete, and both barrels and action are in the finished filed state.

30. Smooth-bored barrels converted into choke-bored barrels shall be subjected to a further definitive proof according to the Scale No. 4 provided for the Sixth Class.

31. All choke-bored barrels sent for proof shall be declared in writing before proof to be so, and unless so declared they will be marked as if they were not choke-bored.

32. Barrels for revolving arms shall have the cylinders or chambers with the revolving action attached and complete, and shall be proved with a cartridge containing the maximum service charge which the cylinder or chamber of the arm will receive.

MARKS OF PROOF.

33. The marks denoting provisional proof shall be as follows, that is to say:

As to the Gunmakers' Company. — The letters "G P" interlaced in a cypher surmounted by a lion rampant (videlicet).

As to the Guardians. —The letters "B P" interlaced in a cypher surmounted by a crown (videlicet).

34. The marks denoting definitive proof shall be as follows, that is to say:

As to the Gunmakers' Company.—The letters "G P" interlaced in a cypher surmounted by a crown, and the view mark being the letter "V" surmounted by a crown (videlicet).

As to the Guardians.—Two sceptres crossed, a crown in the top angle formed by the crossing of the sceptres, the letter "B" in the proper right angle, the letter "C" in the proper left angle, and the letter "P" in the lower angle, and the view mark being two sceptres crossed, a crown in the top angle formed by the crossing of the sceptres, and in the lower angle the letter "V" (videlicet).

35. The marks denoting the provisional proof of barrels proved in the state for definitive proof shall be as follows:

As to the Gunmakers' Company. — The letters "V G P" interlaced in a cypher surmounted by a lion rampant (videlicet).

As to the Guardians.—The letters "V B P" interlaced in a cypher surmounted by a crown (videlicet).

MODE OF AFFIXING PROOF MARKS.

36. On arms of the First, Third, and Fifth Classes, the definitive proof mark and view mark shall be impressed at the breech end of the barrel, and if the barrel is constructed with a patent breech, or with revolving cylinders or chambers, the view mark shall be also impressed upon the breech or upon every cylinder or chamber, if more than one, with which the barrel is connected.

37. On arms of the Second Class, and single-barrelled arms of the Fourth, Sixth, Seventh, and Eighth Classes proved provisionally and definitively, the provisional proof mark shall be impressed on the round of the barrel near the breech end, and the definitive proof mark and view mark shall be impressed upon the barrel above the provisional proof mark, and if the barrel be constructed with a patent breech, or with a breech-loading action, or with a breech block or chamber, the view mark shall be also impressed upon the patent breech, breech-loading action, shoe, breech block, or chamber, with which the barrel is connected.

38. On arms of the Fourth, Sixth, Seventh, and Eighth Classes being double breech-loaders, the barrels for which have been submitted for provisional proof before being put together, the provisional proof mark shall be impressed upon the round of the barrels near the breech, in front of the flats, or in a corresponding position when there are no flats, and the definitive proof mark and view mark shall be impressed upon the flats or in a corresponding position when there are no flats. If provisionally proved after being put together, the provisional proof mark shall be impressed upon the flats at the breech end, or in a corresponding position, and the definitive proof mark and view mark shall be impressed immediately following the provisional proof mark. The view mark shall also be impressed upon the action or shoe, breech block or blocks, chamber or chambers with which the barrels are connected.

39. On arms of the Second, and single breech-loading and muzzle-loading arms of the Fourth Classes proved provisionally in the state for definitive proof, the proof mark shall be impressed in the same position as the view mark occupies according to Rules 37 and 38.

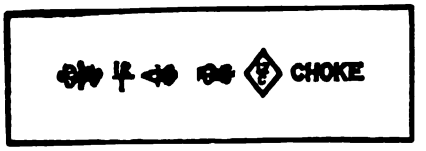
40. On all barrels the gauge size of the barrel shall be impressed at the definitive proof, and on all barrels for breech-loading arms, of the Fourth, Sixth, and Eighth Classes, the chamber gauge size, together with the letter "C," signifying Chamber, shall also be impressed following the definitive proof and view marks, and shall be inclosed in a device, thus:

41. In all smooth-bore and choke-bored barrels, from 4 to 10 gauge inclusive, the gauge shall be divided into three parts, and be marked accordingly: thus the divisions of gauge 8 would be marked 8, ⅛, ⅛; from 11 to 17 inclusive, the gauges shall be divided into two parts: thus the divisions of gauge 12 would be 12, ½; all lesser gauges shall be marked as set forth in the schedule hereto. In all smooth-bore and choke-bored breech-loading barrels the gauge size of the barrel shall be taken at a point 9in. from the breech end. In all other barrels the gauge size shall be taken at the muzzle.

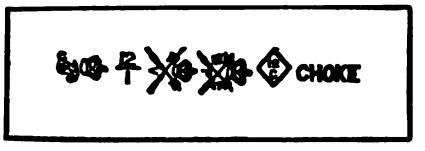
42. On barrels for arms of the Sixth Class the additional mark "Choke" shall be impressed, following the chamber gauge. On arms of the Eighth Class the letter "B" shall be impressed immediately preceding the word Choke, thus: "B CHOKE."

43. The following illustrates the mode of marking arms of the Sixth Class:

As to the Gunmakers' Company.

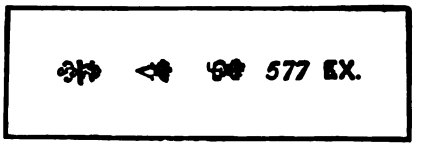


As to the Guardians.

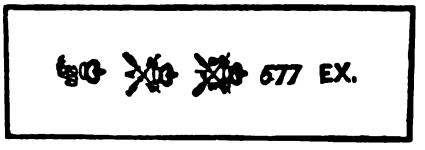


44. The following illustrates the mode of marking arms of the Seventh Class:

As to the Gunmakers' Company.



As to the Guardians.



45. All barrels proved as directed in No. 22 of these Rules shall be marked additionally with the letter "L," incorporated with the chamber gauge, thus .....

46. Barrels proved according to No. 10 *of these Rules shall be marked "Nitro Proof oz. maximum," indicating the service weight of shot to be used.*

47. Barrels proved according to No. 11 *of these Rules, shall be marked E.C. for powder known as "E.C," and* SCH. *for powder known as "Schultze," and for any other Nitro Powder, a suitable abbreviation indicating the same together with numbers showing the maximum service charges of powder in grains, and shot in ounces, that may be used, as for example: "Maxm. Sch. 45 Grs., Shot 1¼oz."*

48. Barrels proved according to No. 23 of these Rules shall have the service charge marked in drachms and ounces, following the proof and view marks.

49. When a barrel of any arm, which barrel has been Proved Definitively, or which has been proved in the state for Definitive Proof but according to the scale for Provisional Proof, is brought to the Proof House, or any branch Proof House of either of the said two Companies, to be proved again Definitively, or according to the scale for Provisional Proof, if such barrel upon being so proved again does not stand proof, the person or persons respectively, who, under the said Act, is or are entitled to impress marks of proof on such barrel, shall efface all the existing marks of Definitive Proof therefrom.

SCALE No. 1.

Scale for Proof of Rifled Small Arms of every Description, except those of the Eighth Class, and except for the Definitive Proof of Arms of the Seventh Class.

Number of Gauge.	Diameter of Bore.	Bullet for Proof.				Charge of Powder for				Service Charge.			
		Diameter.	Length.	Ratio of Length to Diameter.	Weight.	Provisional Proof.		Definitive Proof.		Powder.		Ball.	
	in.	in.	in.		grs.	grs.	oz.drs.	grs.	oz.drs.	grs.	oz.drs.	grs.	
1	1·669	1·649	2·474	1·500	15186	3417	7 13	2278	5 3½	1139	2 9½	11390	
	1·500	1·480	2·220	1·500	10977	2470	5 10½	1646	3 12½	823	1 14	8233	
2	1·325	1·305	1·958	1·500	7527	1694	3 14	1129	2 9½	565	1 4½	5645	
	1·250	1·230	1·845	1·500	6301	1418	3 3½	945	2 2½	473	1 1½	4726	
3	1·157	1·137	1·706	1·500	4978	1120	2 9	747	1 11½	373	0 13½	3734	
4	1·052	1·032	1·548	1·500	3722	837	1 14½	558	1 4½	279	0 10½	2791	
	1·000	·980	1·470	1·500	3187	717	1 10½	478	1 1½	239	0 8½	2390	
5	·976	·956	1·434	1·500	2958	666	1 8½	444	1 0½	222	0 8	2219	
6	·919	·899	1·349	1·500	2461	554	1 4½	369	0 13½	185	0 6½	1846	
	·900	·880	1·320	1·500	2307	519	1 3	346	0 12½	173	0 6½	1731	
7	·873	·853	1·280	1·500	2102	473	1 1½	315	0 11½	158	0 5½	1577	
	·850	·830	1·245	1·500	1936	436	1 0	290	0 10½	145	0 5½	1452	
8	·835	·815	1·223	1·500	1834	413	0 15	275	0 10	138	0 5	1375	
9	·803	·783	1·175	1·500	1626	366	0 13½	244	0 9	122	0 4½	1220	
	·800	·780	1·170	1·500	1607	362	0 13½	241	0 8½	121	0 4½	1205	
10	·775	·755	1·132	1·500	1457	328	0 12	219	0 8	109	0 4	1092	
	·770	·750	1·126	1·501	1430	322	0 11½	215	0 7½	107	0 4	1072	
	·760	·740	1·112	1·503	1375	310	0 11½	207	0 7½	103	0 3½	1031	
11	·751	·731	1·100	1·505	1327	301	0 11	200	0 7½	100	0 3½	995	
	·750	·730	1·099	1·505	1322	300	0 11	200	0 7½	100	0 3½	992	
	·740	·720	1·085	1·507	1270	289	0 10½	193	0 7	96	0 3½	952	
	·733	·713	1·071	1·509	1219	279	0 10½	186	0 6½	93	0 3½	914	
12	·729	·709	1·070	1·509	1214	278	0 10½	185	0 6½	93	0 3½	911	
	·720	·700	1·058	1·511	1170	269	0 9½	180	0 6½	90	0 3½	878	
13	·710	·690	1·045	1·514	1123	260	0 9½	173	0 6½	87	0 3½	842	
	·700	·680	1·032	1·518	1077	252	0 9½	170	0 6½	85	0 3	808	
14	·693	·673	1·024	1·521	1047	246	0 9	170	0 6½	85	0 3	785	
	·690	·670	1·020	1·523	1034	244	0 9	170	0 6½	85	0 3	775	
	·680	·660	1·009	1·529	992	236	0 8½	170	0 6½	85	0 3	744	
15	·677	·657	1·006	1·531	980	235	0 8½	170	0 6½	85	0 3	735	
	·670	·650	·999	1·537	953	230	0 8½	170	0 6½	85	0 3	715	
16	·662	·642	·992	1·545	923	226	0 8½	170	0 6½	85	0 3	692	
	·650	·640	·990	1·547	915	225	0 8½	170	0 6½	85	0 3	687	
	·650	·630	·982	1·559	880	220	0 8	170	0 6½	85	0 3	660	
17	·649	·629	·981	1·560	876	220	0 8	170	0 6½	85	0 3	657	
	·640	·620	·977	1·575	848	217	0 8	170	0 6½	85	0 3	636	
18	·637	·617	·975	1·581	838	216	0 8	170	0 6½	85	0 3	628	
	·630	·610	·974	1·596	818	214	0 7½	170	0 6½	85	0 3	614	
19	·626	·606	·973	1·606	807	213	0 7½	170	0 6½	85	0 3	605	
	·620	·600	·974	1·623	791	212	0 7½	170	0 6½	85	0 3	594	
20	·615	·595	·975	1·638	779	211	0 7½	170	0 6½	85	0 3	584	
	·610	·590	·978	1·657	768	211	0 7½	170	0 6½	85	0 3	576	
21	·605	·585	·980	1·676	757	210	0 7½	170	0 6½	85	0 3	568	
	·600	·580	·985	1·698	748	209	0 7½	170	0 6½	85	0 3	561	
22	·596	·576	·988	1·715	740	209	0 7½	170	0 6½	85	0 3	555	
	·590	·570	·995	1·746	730	208	0 7½	170	0 6½	85	0 3	547	
23	·587	·567	·999	1·762	725	207	0 7½	170	0 6½	85	0 3	544	
	·580	·560	1·012	1·808	716	205	0 7½	170	0 6½	85	0 3	537	
24	·579	·559	1·015	1·816	716	205	0 7½	170	0 6½	85	0 3	537	
	·577	·557	1·021	1·833	715	205	0 7½	170	0 6½	85	0 3	536	
25	·571	·551	1·043	1·893	715	205	0 7½	170	0 6½	85	0 3	536	
	·570	·550	1·047	1·904	715	205	0 7½	170	0 6½	85	0 3	536	
26	·563	·543	1·074	1·978	715	205	0 7½	170	0 6½	85	0 3	536	
	·560	·540	1·086	2·012	715	205	0 7½	170	0 6½	85	0 3	536	
27	·556	·536	1·103	2·057	715	205	0 7½	170	0 6½	85	0 3	536	
28	·550	·530	1·128	2·128	715	205	0 7½	170	0 6½	85	0 3	536	
29	·543	·523	1·158	2·214	715	205	0 7½	170	0 6½	85	0 3	536	
	·540	·520	1·171	2·253	715	205	0 7½	170	0 6½	85	0 3	536	
30	·537	·527	1·185	2·292	715	205	0 7½	170	0 6½	85	0 3	536	
31	·531	·511	1·213	2·374	715	205	0 7½	170	0 6½	85	0 3	536	
	·530	·510	1·218	2·388	715	205	0 7½	170	0 6½	85	0 3	536	
32	·526	·506	1·237	2·445	715	205	0 7½	170	0 6½	85	0 3	536	
33	·520	·500	1·267	2·534	715	205	0 7½	170	0 6½	85	0 3	536	
34	·515	·495	1·293	2·612	715	205	0 7½	170	0 6½	85	0 3	536	
35	·510	·490	1·319	2·692	715	205	0 7½	170	0 6½	85	0 3	536	
36	·506	·486	1·341	2·759	715	205	0 7½	170	0 6½	85	0 3	536	
37	·501	·481	1·369	2·846	715	205	0 7½	170	0 6½	85	0 3	536	
	·500	·480	1·375	2·864	715	205	0 7½	170	0 6½	85	0 3	536	
38	·497	·477	1·392	2·918	715	205	0 7½	170	0 6½	85	0 3	536	
39	·492	·472	1·422	3·012	715	205	0 7½	170	0 6½	85	0 3	536	
	·490	·470	1·434	3·051	715	205	0 7½	170	0 6½	85	0 3	536	
40	·488	·468	1·446	3·090	715	205	0 7½	170	0 6½	85	0 3	536	
41	·484	·464	1·471	3·171	715	205	0 7½	170	0 6½	85	0 3	536	
42	·480	·460	1·497	3·254	715	205	0 7½	170	0 6½	85	0 3	536	
43	·476	·456	1·523	3·341	715	205	0 7½	170	0 6½	85	0 3	536	
44	·473	·453	1·544	3·407	715	205	0 7½	170	0 6½	85	0 3	536	
	·470	·450	1·564	3·476	715	205	0 7½	170	0 6½	85	0 3	536	
45	·469	·449	1·571	3·499	715	205	0 7½	170	0 6½	85	0 3	536	

Number of Gauge.	Diameter of Bore.	Bullet for Proof.				Charge of Powder for						Service Charge.		
		Diameter.	Length.	Ratio of Length to Diameter.	Weight.	Provisional Proof.			Definitive Proof.			Powder.		Ball.
	in.	in.	in.		grs.	grs.	oz.	drs.	grs.	oz.	drs.	oz.	drs.	grs.
46	·466	·446	1·592	3·570	715	205	0	7¼	170	0	6¼	85	0 3	536
47	·463	·443	1·614	3·643	715	205	0	7¼	170	0	6¼	85	0 3	536
	·460	·440	1·636	3·718	715	205	0	7¼	170	0	6¼	85	0 3	536
48	·459	·439	1·644	3·744	715	205	0	7¼	170	0	6¼	85	0 3	536
49	·456	·436	1·666	3·822	715	205	0	7¼	170	0	6¼	85	0 3	536
50	·453	·433	1·689	3·902	715	205	0	7¼	170	0	6¼	85	0 3	536
	·451	·431	1·705	3·956	715	205	0	7¼	170	0	6¼	85	0 3	536
51·05	·450	·430	1·711	3·978	714	205	0	7¼	170	0	6¼	85	0 3	536
54·61	·440	·420	1·712	4·076	672	203	0	7¼	170	0	6¼	85	0 3	504
58·50	·430	·410	1·690	4·122	631	198	0	7¼	170	0	6¼	85	0 3	473
62·78	·420	·400	1·668	4·170	589	191	0	7	170	0	6¼	85	0 3	442
67·49	·410	·390	1·630	4·180	548	183	0	6¾	170	0	6¼	85	0 3	411
72·68	·400	·380	1·593	4·192	507	174	0	6¼	170	0	6¼	85	0 3	380
78·41	·390	·370	1·574	4·254	481	165	0	6	110	0	4	55	0 2	361
84·77	·380	·360	1·578	4·384	455	155	0	5¾	103	0	3¾	52	0 2	341
91·83	·370	·350	1·583	4·523	429	145	0	5¼	97	0	3½	48	0 1¾	322
99·70	·360	·340	1·588	4·671	403	136	0	5	91	0	3¼	45	0 1¾	302
108·49	·350	·330	1·565	4·742	377	126	0	4¾	84	0	3	42	0 1½	283
118·35	·340	·320	1·563	4·884	352	117	0	4½	78	0	2¾	39	0 1½	264
129·43	·330	·310	1·573	4·945	325	108	0	4	72	0	2½	36	0 1¼	244
141·95	·320	·300	1·514	5·047	300	99	0	3¾	66	0	2½	33	0 1¼	225
156·14	·310	·290	1·465	5·052	273	90	0	3¼	60	0	2¼	30	0 1	205
172·28	·300	·280	1·425	5·089	248	82	0	3	55	0	2	27	0 1	186

SCALE No. 2.

Scale for Definitive Proof of Arms of the Seventh Class. (Express Rifles.)

Number of Gauge.	Definitive Proof.				Service Charge.			
	Powder.		Bullet.		Powder.		Bullet.	
	grs.	drs.	grs.		grs.	drs.	grs.	
·577	330	12	800		165	6	600	
·500	300	11	587		150	5½	440	
·450	240	8½	573		120	4¼	430	
·400	170	6	293		85	3	220	
·360	100	3½	173		50	1¾	130	

SCALE No. 3.

Scale for Proof of Small Arms of every Description except Rifled Small Arms and Arms of the Fourth and Sixth Classes.

No. of Gauge.	Diameter of Bore by Calculation.	Bullets for Proof.		Charges of Powder for Proof.													
				First Class.			Second Class.				Third Class.						
		Diameter.	Weight.	Definitive Proof.			Provisional Proof.			Definitive Proof.		Provisional Proof.			Definitive Proof.		
	in.	in.	gr.	gr.	oz.	dr.	gr.	oz.	dr.	gr.	oz. dr.	gr.	oz.	dr.	gr.	oz.	dr.
A	2·000	1·980	11682	—			—			—		8214	18	12½	5841	13	5½
B	1·938	1·918	10618	—			—			—		7466	17	1	5309	12	2½
C	1·875	1·855	9606	—			—			—		6754	15	7	4803	10	15½
D	1·813	1·793	8675	—			—			—		6100	13	15	4338	9	14½
E	1·750	1·730	7792	—			—			—		5479	12	8½	3896	8	14½
F	1·688	1·668	6984	—			—			—		4911	11	3¼	3492	7	15½
1	1·669	1·649	6752	—			—			—		4748	10	13¼	3376	7	11½
H	1·625	1·605	6222	—			—			—		4375	10	0	3111	7	1½
J	1·563	1·543	5529	—			—			—		3887	8	14½	2764	6	5
K	1·500	1·480	4879	—			—			—		3431	7	13½	2440	5	9½
L	1·438	1·418	4291	—			—			—		3017	6	14½	2146	4	14½
M	1·375	1·355	3744	—			—			—		2633	6	0½	1872	4	4½
2	1·325	1·305	3342	—			—			—		2350	5	6	1671	3	13
O	1·313	1·293	3253	—			—			—		2287	5	3¾	1627	3	11½
P	1·250	1·230	2800	—			—			—		1969	4	8	1400	3	3½
3	1·157	1·137	2211	1555	3	8¾	1555	3	8¾	778	1 12½		—		1244	2	13½
4	1·052	1·032	1649	1159	2	10½	1159	2	10½	580	1 5½		—		928	2	2
5	·976	·956	1315	925	2	1½	925	2	1½	463	1 1		—		740	1	11
6	·919	·899	1090	766	1	12	766	1	12	383	0 14		—		612	1	6½
7	·873	·853	931	656	1	8	656	1	8	328	0 12		—		525	1	3½
8	·835	·815	812	602	1	6	602	1	6	301	0 11		—		481	1	1½
9	·803	·783	720	492	1	2	492	1	2	246	0 9		—		394	0	14½
10	·775	·755	646	465	1	1	465	1	1	232	0 8½		—		372	0	13½

No. of Gauge.	Diameter of Bore by Calculation.	Bullets for Proof.		Charges of Powder for Proof.													
				First Class.			Second Class.				Third Class.						
		Diameter.	Weight.	Definitive Proof.			Provisional Proof.			Definitive Proof.		Provisional Proof.			Definitive Proof.		
	in.	in.	gr.	gr.	oz.	dr.	gr.	oz.	dr.	gr.	oz. dr.	gr.	oz.	dr.	gr.	oz.	dr.
11	·751	·731	586	437	0	16	437	0	16	219	0 8	—			350	0	12¾
12	·729	·709	535	437	0	16	437	0	16	219	0 8	—			350	0	12¾
13	·710	·690	493	410	0	15	410	0	15	205	0 7½	—			328	0	12
14	·693	·673	457	383	0	14	383	0	14	191	0 7	—			306	0	11½
15	·677	·657	425	383	0	14	383	0	14	191	0 7	—			306	0	11½
16	·662	·642	399	369	0	13½	369	0	13½	185	0 6¾	—			295	0	10¾
17	·649	·629	374	369	0	13½	369	0	13½	185	0 6¾	—			295	0	10¾
18	·637	·617	352	342	0	12½	342	0	12½	171	0 6¼	—			273	0	10
19	·626	·606	334	301	0	11	301	0	11	150	0 5½	—			241	0	8¾
20	·615	·595	316	273	0	10	273	0	10	137	0 5	—			219	0	8
21	·605	·585	300	273	0	10	273	0	10	137	0 5	—			219	0	8
22	·596	·576	287	246	0	9	246	0	9	123	0 4½	—			197	0	7½
23	·587	·567	274	246	0	9	246	0	9	123	0 4½	—			197	0	7½
24	·579	·559	262	232	0	8½	232	0	8½	116	0 4¼	—			186	0	6¾
25	·571	·551	251	232	0	8½	232	0	8½	116	0 4¼	—			186	0	6¾
26	·563	·543	242	232	0	8½	232	0	8½	116	0 4¼	—			186	0	6¾
27	·556	·536	231	232	0	8½	232	0	8½	116	0 4¼	—			186	0	6¾
28	·550	·530	223	232	0	8½	232	0	8½	116	0 4¼	—			186	0	6¾
29	·543	·523	214	205	0	7½	205	0	7½	102	0 3¾	—			164	0	6
30	·537	·517	207	205	0	7½	205	0	7½	102	0 3¾	—			164	0	6
31	·531	·511	—	205	0	7½	205	0	7½	102	0 3¾	—			164	0	6
32	·526	·506	194	205	0	7½	205	0	7½	102	0 3¾	—			164	0	6
33	·520	·500	—	191	0	7	191	0	7	96	0 3½	—			153	0	5½
34	·515	·495	182	191	0	7	191	0	7	96	0 3½	—			153	0	5½
35	·510	·490	—	191	0	7	191	0	7	96	0 3½	—			153	0	5½
36	·506	·486	172	191	0	7	191	0	7	96	0 3½	—			153	0	5½
37	·501	·481	—	191	0	7	191	0	7	96	0 3½	—			153	0	5½
38	·497	·477	162	178	0	6½	178	0	6½	89	0 3¼	—			142	0	5¼
39	·492	·472	—	178	0	6½	178	0	6½	89	0 3¼	—			142	0	5¼
40	·488	·468	154	178	0	6½	178	0	6½	89	0 3¼	—			142	0	5¼
41	·484	·464	—	164	0	6	164	0	6	82	0 3	—			131	0	4¾
42	·480	·460	146	164	0	6	164	0	6	82	0 3	—			131	0	4¾
43	·476	·456	—	164	0	6	164	0	6	82	0 3	—			131	0	4¾
44	·473	·453	139	164	0	6	164	0	6	82	0 3	—			131	0	4¾
45	·469	·449	—	150	0	5½	150	0	5½	75	0 2¾	—			120	0	4¼
46	·466	·446	133	150	0	5½	150	0	5½	75	0 2¾	—			120	0	4¼
47	·463	·443	—	150	0	5½	150	0	5½	75	0 2¾	—			120	0	4¼
48	·459	·439	127	150	0	5½	150	0	5½	75	0 2¾	—			120	0	4¼
49	·456	·436	—	150	0	5½	150	0	5½	75	0 2¾	—			120	0	4¼
50	·453	·433	122	150	0	5½	150	0	5½	75	0 2¾	—			120	0	4¼

SCALE No. 4.

Scale for Proof of Smooth Bore Arms of the Fourth, and Arms of the Sixth and Eighth Classes.

MUZZLE-LOADING.

Number of Gauge.	Diameter of Bore by Calculation.	Provisional Proof.		Definitive Proof.				Service Charge.			
		Powder	Bullet.	Powder.		Shot.		Powder.		Shot.	
		grs.	drs.	grs.		grs.	oz.	grs.	drs.	grs.	oz.
4	1·052	928	34	1649		547	20	2041	4¾	273	10	1531	3½
5	·976	740	27	1315		426	15 2/16	1623	3¼	213	7½	1217	2¾
6	·919	612	22½	1090		357	13 1/16	1367	3	179	6 7/16	1025	2¼
7	·873	525	19¼	931		308	11½	1185	2¼	154	5⅝	889	2 1/16
8	·835	481	17½	812		270	9⅞	1057	2 1/16	135	4 15/16	793	1¾
9	·803	394	14½	720		244	8 11/16	967	2 1/16	122	4 5/16	725	1¾
10	·775	372	13½	646		219	8	875	2	109	4	656	1½
11	·751	350	12¾	586		191	7	765	1¾	96	3½	574	1 5/16
12	·729	350	12¾	535									
13	·710	323	12	493		178	6½	729	1⅝	89	3¼	547	1¼
14	·693	306	11¼	457									
15	·677	306	11¼	425		164	6	656	1½	82	3	492	1⅛
16	·662	295	10¾	399									
17	·649	295	10¾	374		150	5½	583	1⅓	75	2¾	437	1
18	·637	273	10	352									
19	·626	241	8¾	334									
20	·615	219	8	316		136	5	511	1⅛	68	2½	383	0⅞
21	·605	219	8	300									
22	·596	197	7¼	287									
23	·587	197	7¼	274									
24	·579	186	6¾	262									
25	·571	186	6¾	251									
26	·563	186	6¾	242		109	4	437	1	55	2	328	0¾
27	·556	186	6¾	231									
28	·550	186	6¾	223									
29	·543	164	6	214									
30	·537	164	6	207									

Number of Gauge.	Diameter of Bore by Calculation.	Provisional Proof.		Definitive Proof.		Service Charge.	
		Powder	Bullet.	Powder.	Shot.	Powder.	Shot.
		grs. drs.	grs.	grs. drs.	grs. oz.	grs. drs.	grs. oz.
31	·531	164 6	200				
32	·526	164 6	194				
33	·520	153 5½	188				
34	·515	153 5½	182				
35	·510	153 5½	177	82 3	328 0⅝	41 1½	246 0$\frac{5}{16}$
36	·506	153 5½	172				
37	·501	153 5½	167				
38	·497	142 5½	162				
39	·492	142 5½	158				
40	·488	142 5½	154				
41	·484	131 4½	150				
42	·480	131 4½	146				
43	·476	131 4½	142				
44	·473	131 4½	139				
45	·469	120 4½	136	55 2	219 0½	27 1	164 0⅜
46	·466	120 4½	133				
47	·463	120 4½	130				
48	·459	120 4½	127				
49	·456	120 4½	124				
50	·453	120 4½	122				

BREECHLOADING.

In the following table, barrels for arms of the Eighth Class must be proved with one-and-one-half times the service charge of lead (see Rule 16).

Number of Gauge.	Diameter of Bore by Calculation.	Provisional Proof.		Definitive Proof.		Service Charge.	
		Powder	Bullet.	Powder.	Shot.	Powder.	Shot.
		grs. drs.	grs.	grs. drs.	grs. oz.	grs. drs.	grs. oz.
4	1·052	923 34	1649				
	1·026	—	—				
	1·001	—	—				
5	·976	740 27	1315	492 18	1749 4	246 9	1312 3
	·957	—	—				
	·938	—	—				
6	·919	612 22½	1090				
	·903	—	—				
	·888	—	—				
7	·873	525 19½	931				
	·860	—	—				
	·847	—	—				
8	·835	481 17⅞	812	328 12	1167 2⅔	164 6	875 2
	·824	—	—				
	·813	—	—				
	·803	394 14½	720				
	·793	—	—				
	·784	—	—				
10	·775	372 13½	646	219 8	875 2	109 4	656 1½
	·763	—	—				
11	·751	350 12⅔	586				
	·740	—	—				
12	·729	350 12⅔	535	178 6½	729 1⅔	89 3¼	547 1⅓
	·719	—	—				
13	·710	328 12	493				
	·701	—	—				
14	·693	306 11½	457	164 6	656 1½	82 3	492 1⅛
	·685	—	—				
15	·677	306 11½	425				
	·669	—	—				
16	·662	295 10⅔	399				
	·655	—	—	150 5½	583 1⅓	75 2¾	437 1
17	·649	295 10⅔	374				
18	·637	273 10	352				
19	·626	241 8⅔	334				
20	·615	219 8	316	137 5	511 1⅛	68 2½	383 0⅞
21	·605	219 8	300				
22	·596	197 7½	287				
23	·587	197 7½	274				
24	·579	186 6⅔	262				
25	·571	186 6⅔	251				
26	·563	186 6⅔	242	109 4	437 1	55 2	328 0⅔
27	·556	186 6⅔	231				
28	·550	186 6⅔	223				
29	·543	164 6	214				
30	·537	164 6	207	82 3	292 0⅔	41 1½	219 0½
31	·531	164 6	200				
32	·526	164 6	194				

SCALE NO. 5.

Scale of Supplementary Proof, with Powder "T. S. 2" for Arms of the Fourth, Sixth, and Eighth classes, in which Nitro Powders are to be used:

No. of Gauge.	Charge of Powder, T. S. 2.		Charge of Shot.	
	Grains.	Drams.	Grains.	Ounces.
8	192	7	1167	2⅔
10	139	5	875	2
12	114	4½	729	1⅔
12 extra	125	4½	729	1⅔
14	113	4⅛	656	1½
16	104	3⅞	583	1⅓
20	96	3½	510	1⅛
28	80	3	437	1

SCALE NO. 6.

Scale of ordinary Service Charges for Arms of the Fourth, Sixth, and Eighth classes, to be used with Nitro Powders.

Gauge.	Schultze.	E.C.	Amberite.	Coopal's.	S.S.	Cannonite.	Ballistite.	Walsrode.
	grs. oz.	grs. oz.	grs. oz.	grs. oz.	grs. oz.	grs. oz.	grs. oz.	grs. oz.
4	3	3	3	3	3			
8	85 2	83 2						
10	49 1½	49 1½	46 1½	49 1½	49 1½			
12	42 1⅛	42 1⅛	40 1⅛	42 1⅛	43 1⅛	35 1⅛	25½ 1⅛	32 1⅛
12 extra	46 1¼	45 1¼	45 1¼	45 1¼	46 1¼	37 1¼	29 1¼	35 1¼
14	40 1⅛	40 1⅛	38 1⅛	40 1⅛	40 1⅛			
16	37 1	37 1	35 1	38 1	38 1			
20	33 ⅞	33 ⅞	33 ⅞	35 ⅞	35 ⅞			
24	28 ¾	28 ¾		28 ¾	28 ¾			
28								

SCHEDULE C.

Maximum Prices for Proof.

No. of Gauge.	First and Second Classes.			Third Class.		Fourth, Sixth, Seventh, and Eighth Classes.					Fifth Class.	
	Provisional Proof.	Definitive Proof.	Pistols.	Twisted Barrels.	Plain Barrels.	Provisional Proof.	Definitive Proof.	Breech-loading Arms.	T. S. 2 Proof.	Nitro Proof.	Revolving Carbines.	Revolving Pistols.
	s. d.	s. d.		s. d.	s. d.	s. d.						
1	3 6	3 6	Of all sizes, 2¾d. each, plain Iron, Definitive Proof by Percussion, 2¾d. each.	3 6	3 6	3 6	Same Prices as Provisional Proof of the same Class.	1s. 6d. each.	1s 0d. each.	1s. 0d. each.	Not exceeding 6 Shots, 2s. 0d. each complete Arm; exceeding that number, 4d. per shot.	Not exceeding 6 Shots, 1s. 6d. each complete Pistol; exceeding that number, 3d. per shot.
2	3 6	3 6		3 6	3 6	3 6						
3	2 0	2 0		2 0	2 0	2 0						
4	2 0	2 0		2 0	2 0	2 0						
5	2 0	2 0		2 0	2 0	2 0						
6	1 0	1 0		1 0	1 0	1 0						
7	0 9	0 9		0 9	0 9	0 9						
8	0 9	0 9		0 9	0 9	0 9						
9	0 9	0 9		0 9	0 9	0 9						
10	0 9	0 9		0 9	0 9	0 9						
11	0 3	0 4		0 6	0 3	0 6						
12	0 3	0 4		0 6	0 3	0 6						
13	0 3	0 4		0 6	0 3	0 6						
14	0 3	0 4		0 6	0 3	0 6						
15	0 3	0 4		0 6	0 3	0 6						
16	0 3	0 4		0 6	0 3	0 6						
17	0 3	0 4		0 6	0 3	0 6						
18	0 3	0 4		0 6	0 3	0 6						
19	0 3	0 4		0 6	0 3	0 6						
20	0 3	0 4		0 6	0 3	0 6						
21	0 3	0 4		0 6	0 3	0 6						
22	0 3	0 4		0 6	0 3	0 6						
23	0 3	0 4		0 6	0 3	0 6						
24	0 3	0 4		0 6	0 3	0 6						
25	0 3	0 4		0 6	0 3	0 6						
26	0 3	0 4		0 6	0 3	0 6						
27	0 3	0 4		0 6	0 3	0 6						
28	0 3	0 4		0 6	0 3	0 6						

SCHEDULE C—*continued.*

	First and Second Classes.				Third Class.		Fourth, Sixth, Seventh, and Eighth Classes.					Fifth Class.	
	Provisional Proof.	Definitive Proof.	Pistols.		Twisted Barrels.	Plain Barrels	Provisional Proof.	Definitive Proof.	Breech-loading Arms.	T. S. 3 Proof.	Nitro Proof.	Revolving Carbines.	Revolving Pistols.
		s. d.			s. d.	s. d.	s. d.						
29	0 3	0 4	Of all sizes, 2½d. each, plain Iron. 3d. each twisted. Definitive Proof by Percussion, 2½d. each.		0 6	0 3	0 6	Same Prices as Provisional Proof of the same Class.	1s. 6d. each.	1s. 0d. each.	1s. 0d. each.	Not exceeding 6 Shots, 2s. 0d. each complete Arm; exceeding that number, 4d. per shot.	Not exceeding 6 Shots, 1s. 6d. each complete Pistol; exceeding that number, 3d. per shot.
30	0 3	0 4			0 6	0 3	0 6						
31	0 3	0 4			0 6	0 3	0 6						
32	0 3	0 4			0 6	0 3	0 6						
33	0 3	0 4			0 6	0 3	0 6						
34	0 3	0 4			0 6	0 3	0 6						
35	0 3	0 4			0 6	0 3	0 6						
36	0 3	0 4			0 6	0 3	0 6						
37	0 3	0 4			0 6	0 3	0 6						
38	0 3	0 4			0 6	0 3	0 6						
39	0 3	0 4			0 6	0 3	0 6						
40	0 3	0 4			0 6	0 3	0 6						
41	0 3	0 4			0 6	0 3	0 6						
42	0 3	0 4			0 6	0 3	0 6						
43	0 3	0 4			0 6	0 3	0 6						
44	0 3	0 4			0 6	0 3	0 6						
45	0 3	0 4			0 6	0 3	0 6						
46	0 3	0 4			0 6	0 3	0 6						
47	0 3	0 4			0 6	0 3	0 6						
48	0 3	0 4			0 6	0 3	0 6						
49	0 3	0 4			0 6	0 3	0 6						
50	0 3	0 4			0 6	0 3	0 6						

These prices apply to barrels of the gauges numbered 1 to 50 as above. For the proof of barrels the bore of which exceeds No. 1 Gauge, the price shall be three shillings and sixpence for each proof, whether provisional or definitive, and for barrels of smaller size than those above specified, the same price shall be charged as for the smallest size of barrel above specified.

Made and done under the Common Seal of the Gunmakers' Company of the City of London.

The Common Seal of the Gunmakers' Company of the City of London was hereunto affixed in the presence of

H. Brandon-White, Master.

Fredk. T. Aston, Clerk.

L.S.

Made and done under the Common Seal of the Guardians of the Birmingham Proof House.

The Common Seal of the Guardians of the Birmingham Proof House was hereunto affixed in the presence of

Chas. Playfair, Chairman.

Joseph Rowlands, Law Clerk.

L.S.

I approve of the foregoing Rules, Regulations, and Scales for Proof.

LANSDOWNE.

War Office, March 10, 1896.

BIRMINGHAM PROOF HOUSE STATISTICS.

(*Field*, March 21, 1896; vol. 87, page 419.)

IN the revenue account of the Gun Barrel Proof House of Birmingham for the year ending Dec. 31, 1895, the following particulars are given relative to the barrels which have been submitted to the definite proofs, and the sums paid for them:

			£ s. d.
15,453	twisted double birding barrels, one proof only...	at 2½d.	160 19 4½
1,306	Do. do. 2nd proof	,, 2½d.	13 12 1
2,889	plain iron and steel double birding barrels, one proof only.....	,, 2d.	24 1 6
888	plain iron and steel double birding barrels, 2nd proof	,, 2d.	7 8 0
23	breechloading birding barrels, one proof only...	,, 4d.	0 7 8
68	Do. do.	,, 4½d.	1 5 6
524	Do. do.	,, 5d.	10 18 4
861	Do. (Foreign) do.	,, 4d.	14 7 0
511	Do. (do.) do.	,, 4½d.	9 11 7½
8,057	Do. 2nd proof	,, 4d.	134 5 8
14,659	Do. do.	,, 4½d.	274 17 1½
6,036	Do. do.	,, 5d.	125 15 0
1,260	Do. do.	,, 6d.	31 10 0
467	Do. (Express Rifles).....	,, 8d.	15 11 4
107	Do. (E.C. and Schultze)	,, 1/6	8 0 6
1,859	Do. (Foreign) 2nd proof	,, 4d.	30 19 8
3,059	Do. (do.) do.	,, 4½d.	57 7 1½
144	Do. large bore barrels, 2nd proof	,, 9d.	5 8 0
26	Do. do. do. do. ...	,, 1/-	1 6 0
1	Do. do. do. do. ...	,, 2/6	0 2 6
4	Do. do. do. do. ...	,, 3/6	0 14 0
1	Do. do. do. do. ...	,, 20/5	1 5 0
7,397	Do. choke bore barrels do. ...	,, 4d.	123 5 8
12,176	Do. do. do. do. ...	,, 4½d.	228 6 0
2,691	Do. do. do. do. ...	,, 5d.	56 1 3
514	Do. do. do. do. ...	,, 6d.	12 17 0
25	Do. do. (long cases) do. ...	,, 6d.	0 12 6
167	Do. large bore, choke bore barrels, do. ...	,, 9d.	6 5 3
2	Do. do. do. do. ...	,, 1/6	0 3 0
1	Do. do. do. do. ...	,, 2/-	0 2 0
194	breechloading military barrels, one proof only...	,, 5d.	4 0 10
138	Do. do. (Foreign) do. ...	,, 5d.	2 17 6
6,160	Do. do. 2nd proof.....	,, 4d.	102 13 4
8,577	Do. do. do.	,, 5d.	178 13 9
9,119	Do. do. (Foreign), 2nd proof	,, 5d.	189 19 7
28,853	revolving pistol chambers, one proof only.....	,, 1d.	120 4 5
11,705	Do. do. (Foreign), one proof only	,, 1d.	48 15 5
112	Do. do. one proof only	,, 1½d.	0 14 0
243	Do. do. (Foreign), one proof only	,, 1½d.	1 10 4½
146,177			2,006 14 10½

Out of the many thousands of breechloading guns that are proved, it will be observed how very few are submitted to the optional proof for nitro powders. Only 107 were proved with E.C. and Schultze, as stated above, and none with any other description of gunpowder, as was also permissible under Sect. 10 of the Proof Regulations of 1887. Sect. 10 is now further amended, under the new rules of 1896, as shown *ante*, page 3.

EXPERIMENTS ON THE STRENGTH OF GUNBARRELS.

(*Field*, March 7, 1891; vol. 77, p. 325.)

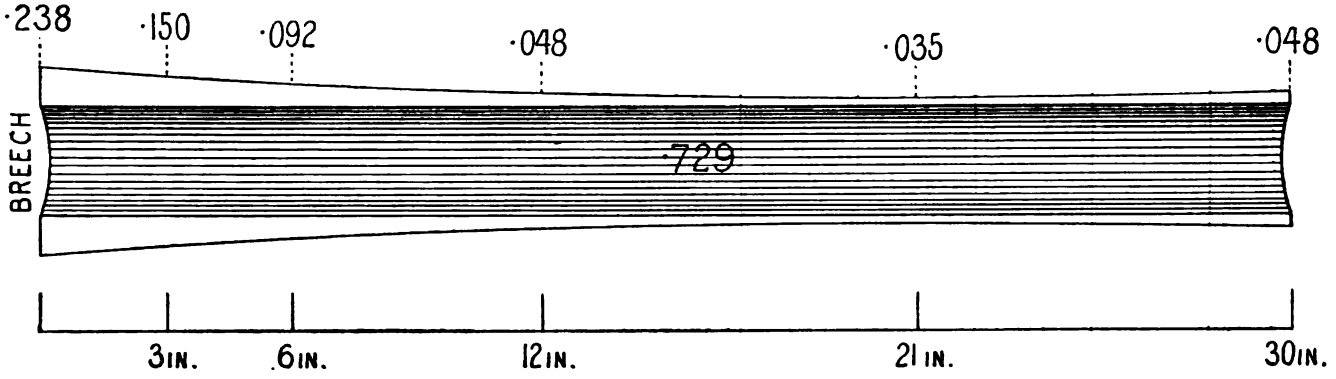
THE Birmingham Proof-house Board have had a committee engaged, during two years, in carrying out a most important series of experiments, the object of which was to test the strength of the various kinds of English and foreign barrels employed in the manufacture of sporting guns. Thirty-nine samples, of three barrels each, were put to the test, and among them were included steel made by different processes, Damascus of various kinds (some hand-forged and some machine-forged), besides other varieties, particulars of which will be found in the tables given below. The barrels were all of 12-gauge, bored perfectly cylindrical inside, and turned to exactly the same dimensions outside, the measurement of which varied at different parts of the barrel, as stated in the report; but an idea of the relative thickness of metal may be more readily formed by reference to the diagram given herewith. The curve of the metal, however, appears in the woodcut to be much more rapid than it would actually be in the barrel, owing to the length being reduced in scale, in order to bring the woodcut within the dimensions of the page.

It will be observed that the greatest thickness of the metal, at the breech, is 238 thousandths of an inch; it diminishes to ·150 at 3in., and to ·092 at 6in.; at a foot from the breech it is ·048, or about one-fifth of the original substance; and its thinnest part is reached at 21in., where it is reduced to ·035. Beyond this point it increases again, and at the muzzle has the same substance as it had at 12in. from the breech. These particulars are deserving of attention, as they serve to throw light upon some of the results which occurred in the course of the experiments.

in strength. The number of "cumulative grains" in the first round of proof is obtained by adding altogether the 182 of powder and 729 of shot, thereby making a total of 911. In the next round, this 911 is added to the grains of powder and shot used in the second proof; and so on throughout the subsequent rounds.

	Charge of Powder.		Charge of Shot.	Cumulative grains.
1st proof.....	182grs. (= 6·66drs.)	and	729grs. (=1·67oz.)	911
2nd "	200grs. (= 7·31drs.)	"	802grs. (=1·83oz.)	1913
3rd "	220grs. (= 8·04drs.)	"	882grs. (=2·02oz.)	3015
4th "	242grs. (= 8·85drs.)	"	970grs. (=2·23oz.)	4227
5th "	256grs. (= 9·36drs.)	"	1018grs. (=2·32oz.)	5501
6th "	269grs. (= 9·84drs.)	"	1069grs. (=2·44oz.)	6839
7th "	282grs. (=10·31drs.)	"	1122grs. (=2·56oz.)	8243
8th "	296grs. (=10·83drs.)	"	1178grs. (=2·69oz.)	9717
9th "	310grs. (=11·34drs.)	"	1236grs. (=2·82oz,)	11263
10th "	325grs. (=11·88drs.)	"	1296grs. (=2·96oz.)	12884
11th "	341grs. (=12·47drs.)	"	1361grs. (=3·11oz.)	14586
12th "	358grs. (=13·09drs.)	"	1429grs. (=2·27oz.)	16373

It will here be seen that the tests commenced with about 6¾drs. of powder and 1⅛oz. of shot, and increased to about 13drs. of powder and 3¼oz. of shot, and that the proportion of powder to lead was approximately 1 to 4 throughout. But the rate of progression was not uniform, as the first increase in the powder charge was 18grs., the next 20, and then 22, after which there was a drop to 14 and 13,



In the ordinary mode of procedure, the first or provisional proof of gunbarrels is made with a very large charge of powder (12¾drs. for a 12-bore) and a spherical ball 20 thousandths of an inch smaller than the calibre of the barrel—which ball consequently offers very little resistance to the expansion of the powder gases. But after the barrels have advanced to a comparatively finished stage, they undergo a second or definitive proof, in which the powder is reduced to 6½drs., and a heavy charge of No. 6 shot (1⅛oz.) is substituted for the loose ball, whereby the test is rendered much more effective. The provisional proof, however, does not concern sportsmen so much as gunmakers, to whom it is chiefly of value from its enabling them to ascertain whether the tubes are sound before they incur expense in working them up into guns.

In the experiments now under consideration, the provisional proof was dispensed with, and the test commenced with a charge which was almost identical with the ordinary definitive proof; and from this starting point the severity of the test was gradually increased for a dozen stages, as shown in the next column, in which we give the weights of powder and shot in drams and ounces as well as grains, the heavier weights being more familiar to the majority of sportsmen; but, owing to the variation in the charges, we are obliged to use decimal fractions, instead of the usual quarters and eighths. In the last column we append a list of the cumulative grains for each of the series of proof trials, as the "figures of merit" are derived from the total number of these points, and a comparison of this column with the averages in the official tables will enable the reader to ascertain at a glance whether the three barrels of the same sample were equal

and finally a rise to 16 and 17. We do not see a reason for this irregular course, and think the arrangement would have been simplified by a uniform addition of half a dram of powder and an eighth of an ounce of shot with every grade, in which case the proportion of 1 to 4 would have proceeded regularly in all cases. There is one advantage, however, which arises from the irregularity, and that is, it enables one to ascertain whether the averages recorded were obtained from three tubes of equal or unequal strength.

The barrels were first tried until a slight bulge occurred, the amount of which is not definitely stated, but such as would cause a barrel to be rejected by the proof-master under ordinary circumstances. Afterwards the barrels were further tested until the bulge was increased to ·01, or the hundredth part of an inch; and on the diameter of the bore being thus increased from ·729 to ·739, at any part of the barrel, the testing was discontinued. The full details of the experiments are given in the following official report:

BIRMINGHAM PROOF-HOUSE.

A REPORT UPON TESTING THE STRENGTH OF VARIOUS KINDS OF GUNBARRELS.

The Board of Guardians of the Birmingham Proof-House having by resolution, dated Jan. 26, 1888, appointed a committee to test the strength of the various kinds of English and foreign barrels employed in sporting guns, the said committee was composed of the following

(*Continued on page* 13.)

TABLE I.—Comparative Results of Proving 39 Groups of Different Kinds of Barrels to a "Rejecting" Bulge at the Birmingham Proof-House.

No. in order of merit of endurance.	Register number of group.	Average cumulative grains of powder and shot each barrel endured.	Proportional stress withstood; the definitive proof being 1·00.	Ordinary price per pair of rough tubes in shillings.	NATURE OF MATERIAL OF BARRELS TESTED.
1	18	4248	4·66	29s.	English machine-forged laminated steel, in three rods, improved economic compound coiling process.
2	38	4227	4·64	90s.	English fluid compressed steel, Whitworth's process.
3	11	3886	4·26	25s.	English machine-forged best Damascus, in two rods, improved economic compound coiling process.
4	30	3667	4·02	24s.	English steel, Siemens-Martin process, rolled from a hollow mould; slightly harder than No. 29 group.
5	1	3355	3·68	35s.	English hand-forged best Damascus, in four rods.
6	14	3285	3·60	25s.	English machine-forged variegated Damascus, in two rods, improved economic compound coiling process.
7	10	3243	3·56	29s.	English machine-forged best Damascus, in three rods, improved economic compound coiling process.
8	34	3142	3·43	24s.	English steel, basic open hearth process, from hematite pig and scrap, carburised by Darby's filtration process.
9	19	3052	3·35	24s.	English machine-forged laminated steel, in two rods, improved economic compound coiling process.
10	35	3015	3·31	45s.	English steel, "Superior barrel steel."
11	15	2718	2·98	29s.	English machine-forged chequered Damascus, in three rods, improved economic compound coiling process.
12	39	2648	2·90	24s.	Foreign steel, Siemens-Martin process.
13	31	2471	2·70	24s.	English steel, basic open hearth process, from hematite pig and scrap.
14	13	2441	2·70	29s.	English machine-forged variegated Damascus, in three rods, improved economic compound coiling process.
15	24	2414	2·65	12s.	English machine-forged skelp twist.
16	2	2314	2·54	31s.	English hand-forged best Damascus, in three rods.
17	29	2280	2·50	24s.	English steel, Siemens-Martin process, rolled from a hollow mould.
18	7	2047	2·25	15s.	Foreign "Pointillé" twist.
19	9	2016	2·20	31s.	English machine-forged best Damascus, in four rods, improved economic compound coiling process.
20	16	2010	2·20	25s.	English machine-forged chequered Damascus, in two rods, improved economic compound coiling process.
21	12	1963	2·11	31s.	English machine-forged chequered Damascus, in four rods, improved economic compound coiling process.
22	32	1946	2·11	24s.	English steel, basic open hearth process, from hematite pig and scrap, carburised by Darby's filtration process.
23	33	1834	2·00	24s.	English steel, basic open hearth process, from hematite pig and scrap, carburised by Darby's filtration process.
24	25	1613	1·77	31s.	English hand-forged best laminated steel, in three rods.
25	37	1579	1·72	30s.	Foreign Damascus, "Crollé," in three rods.
25	3	1579	1·72	35s.	Foreign Damascus, "Crollé," in four rods.
26	8	1309	1·44	22s.	English machine-forged Boston Damascus, in four rods, improved economic compound coiling process.
27	5	1245	1·37	18s.	Foreign Damascus, in two rods.
27	17	1245	1·37	18s.	English machine-forged Boston Damascus, in three rods, improved economic compound coiling process.
27	40	1245	1·37	24s.	Foreign steel.
28	21	911	1·00	14s.	English machine-forged iron Damascus, in two rods, improved economic compound coiling process.
29	23	638	0·70	13s.	English machine-forged fine skelp twist.
30	6	607	0·69	14s.	Foreign Boston Damascus, in two rods.
30	22	607	0·69	13s.	English machine-forged iron Damascus, single rod.
30	27	607	0·69	24s.	English steel, Siemens-Martin process, rolled from hollow mould.
31	4	304	0·33	20s.	Foreign Damascus, in three rods.
31	26	304	0·33	25s.	English steel, Siemens-Martin process, special mixture of Swedish and English iron, rolled from hollow mould.
31	28	304	0·33	28s.	English steel, best quality, Siemens-Martin process, from pure Swedish iron, drilled in full length.
32	20	000	000	14s.	English machine-forged Boston Damascus in two rods, improved economic compound coiling process.

Note.—No. 36 was withdrawn, as only one pair was supplied.
The figures in Column 4 *below* unity are caused by some of the individuals of the group having failed to stand the definitive proof.

TABLE II.—Comparative Endurance of 39 Different Kinds of Barrels before either Bursting or Exhibiting a Bulge equal to ·01 of an Inch, or an Increase of from ·729 to ·739 Diameter.

Order of merit in TABLE I.	Classes in order of merit of endurance. TABLE II.	Register number of group.	Average cumulative grains of powder and shot each barrel endured.	Proportional stress withstood; the definitive proof being 1·00.	Ordinary price per pair of tubes in shillings.	NATURE OF MATERIAL OF BARRELS TESTED.
4	1st	30	11571	12·59	24s.	English steel, Siemens-Martin process, rolled from a hollow mould; slightly harder than No. 29 group.
6	,,	14	11571	12·59	25s.	English machine-forged variegated Damascus, in two rods, improved economic compound coiling process.
10	,,	35	11571	12·59	45s.	English steel, "Superior barrel steel."
12	,,	39	11571	12·59	24s.	Foreign steel, Siemens-Martin process.
19	,,	9	11571	12·59	31s.	English machine-forged best Damascus, in four rods, improved economic compound coiling process.
20	,,	16	11571	12·59	25s.	English machine-forged chequered Damascus, in two rods, improved economic compound coiling process.
27	,,	40	11571	12·59	24s.	Foreign steel.
8	2nd	34	10720	11·77	24s.	English steel, basic open hearth process, from hematite pig and scrap, carburised by Darby's filtration process.
31	,,	26	10720	11·77	25s.	English steel, Siemens-Martin process, special mixture of Swedish and English iron, rolled from hollow mould.
2	3rd	38	9909	10·88	90s.	English fluid compressed steel, Whitworth's process.
24	,,	25	9909	10·88	31s.	English hand-forged best laminated steel, in three rods.
3	4th	11	9869	10·83	25s.	English machine-forged best Damascus, in two rods, improved economic compound coiling process.
14	,,	13	9869	10·83	29s.	English machine-forged variegated Damascus, in three rods, improved economic compound coiling process.
21	,,	12	9869	10·83	31s.	English machine-forged chequered Damascus, in four rods, improved economic compound coiling process.
31	5th	28	9058	9·94	29s.	English steel, best quality, Siemens-Martin process, from pure Swedish iron, drilled in full length.
30	6th	27	8591	9·43	24s.	English steel, Siemens-Martin process, rolled from hollow mould.
5	7th	1	8248	9·05	35s.	English hand-forged best Damascus, in four rods.
7	,,	10	8248	9·05	29s.	English machine-forged best Damascus, in three rods, improved economic compound coiling process.
9	,,	19	8248	9·05	24s.	English machine-forged laminated steel, in two rods, improved economic compound coiling process.
11	,,	15	8248	9·05	29s.	English machine-forged chequered Damascus, in three rods, improved economic compound coiling process.
13	,,	31	8248	9·05	24s.	English steel, basic open hearth process, from hematite pig and scrap.
26	,,	8	8248	9·05	22s.	English machine-forged Boston Damascus, in four rods, improved economic compound coiling process.
27	,,	17	8248	9·05	18s.	English machine-forged Boston Damascus, in three rods, improved economic compound coiling process.
27	,,	5	8248	9·05	18s.	Foreign Damascus, in two rods.
28	,,	21	8248	9·05	14s.	English machine-forged iron Damascus, in two rods, improved economic compound coiling process.
30	,,	22	8248	9·05	13s.	English machine-forged iron Damascus, single rod.
31	,,	4	8248	9·05	20s.	Foreign Damascus, in three rods.
32	,,	20	8248	9·05	14s.	English machine-forged Boston Damascus, in two rods, improved economic compound coiling process.
22	8th	32	7475	8·20	24s.	English steel, basic open hearth process, from hematite pig and scrap, carburised by Darby's filtration process.
23	,,	33	7475	8·20	24s.	English steel, basic open hearth process, from hematite pig and scrap, carburised by Darby's filtration process.
29	,,	23	7475	8·20	13s.	English machine-forged fine skelp twist.
1	9th	18	6738	7·40	29s.	English machine-forged laminated steel, in three rods, improved economic compound coiling process.
16	,,	2	6738	7·40	1s.	English hand-forged best Damascus, in three rods.
15	10th	24	6702	7·36	12s.	English machine-forged skelp twist.
25	,,	37	6702	7·36	30s.	Foreign Damascus, "Crollé," in three rods.
30	,,	6	6702	7·36	14s.	Foreign Boston Damascus, in two rods.
17	11th	29	5965	6·55	24s.	English steel, Siemens-Martin process, rolled from a hollow mould.
18	12th	7	5263	5·77	15s.	Foreign "Pointillé" twist.
35	13th	3	5228	5·74	35s.	Foreign Damascus, "Crollé," in four rods.

gentlemen (elected Guardians of the Birmingham Proof-House) as being fairly representative of all departments of sporting gun manufacture: Messrs. S. B. Allport, C. G. Bonehill, E. James, W. M. Scott, T. Turner, jun., and T. W. Webley.

The committee at its first meeting sent an invitation to all classes of makers of barrels ordinarily employed in sporting guns to contribute barrels for the purpose. They also purchased from the best foreign makers, or their agents, samples of the same. The samples supplied were as follows:

First— English twisted hand forged; three specimens.
Secondly—English twisted machine forged; seventeen specimens.
Thirdly— Foreign twisted barrels; six specimens.
Fourthly—English steel; eleven specimens.
Fifthly— Foreign steel; two specimens.

In all thirty-nine specimens, or different kinds: in all 117 barrels.

These were received in the rough-bored and ground state. The rough tubes were first set, then touched in a lathe in several places in order to make them quite concentric, and ground true to gauges; then fine-bored and struck up to gauges, and lapped inside to a plug to exactly the same calibre, viz., ·729 of an inch. Finally, they were mounted on a cylindrical mandril of the exact calibre, and spun on dead centres in a lathe, so as to satisfy the committee that they were absolutely concentric.

The length of each barrel was 30in. The external dimensions were: At breech, 1·205 of an inch; at 3in. up, 1·03: at 6in. up, ·913; at 12in. up, ·826; at 21in. up, ·800; at 30in. up (being the muzzle), ·826. The weight varied slightly, according to the density of the different materials, but approximated to 11lb. 9½oz. per tube.

Three several barrels of each specimen were numbered, as—1/1, 1/2, 1/3; 2/1, 2/2, 2/3; 15/1, 15/2, 15/3; 33/1, 33/2, 33/3, &c.

The committee resolved that as soon as a barrel exhibited such a bulge as would cause its rejection by the proofmaster, it should *be rejected*. The barrels were then wiped out and breech plugs were screwed in, having touch-holes all of one size, namely, $\frac{1}{13}$nd of an inch diameter. They were loaded first with the definitive Proof-House charge applicable to the calibre—namely, 182grs. of Proof-House powder; then a wad of paper felt about $\frac{3}{8}$ths thick over the powder; then 729grs. of No. 6 shot, and then the same kind of wad over the shot. The constancy of the strength of the powder was repeatedly checked. The wads would pass down by the pressure of the little finger on them, and were all cut with one punch. The ramming was done by machine, every one with a pressure equal to laying a 10lb. weight on the wad; not bumped at all. Every charge of powder and shot was weighed in grains, in very accurate scales, by two members of the committee to each kind; and the whole of the members attended the loading, ramming down, firing, washing out, and viewing. All the barrels were mixed together indiscriminately, so that the various kinds were not known to the committee until after the viewing and rejection of the whole.

Lots of eight barrels at a time were fired with a train of powder; they lay in a grooved bench and recoiled into sand. After being fired, they were washed out with hot water, and cleaned with oil tow; all signs of lead were removed with a wire brush. They were polished in and outside, and then viewed by the members of the committee, assisted by the proof-master, who thereupon decided whether a barrel had bulged so as to be perceptible, and to be rejected. After the view, and decision that a barrel had failed, the mark and number upon it was referred to, and the result was recorded. The individual barrels were proved with gradually increasing charges of powder and shot. The *first* proof was 182grs. of powder and 729grs. of shot. The *second* proof was 200gs. of powder and 802grs. of shot. The *third* proof was 220grs. of powder and 882grs. of shot. The *fourth* proof was 242grs. of powder and 970grs. of shot. The *fifth* proof was 256grs. of powder and 1018grs. of shot. The *sixth* proof was 269grs. of powder and 1069grs. of shot. The *seventh* proof was 282grs. of powder and 1122grs. of shot. The *eighth* proof was 296grs. of powder and 1178grs. of shot. The *ninth* proof was 310grs. of powder and 1236grs. of shot. The *tenth* proof was 325grs. of powder and 1296grs. of shot. The *eleventh* proof was 341grs. of powder and 1361grs. of shot. The *twelfth* proof was 358grs. of powder and 1429grs. of shot.

The barrels were proved throughout indiscriminately with the first-proof charge, and if any one, on being viewed, exhibited a rejecting bulge, it was stamped R 1 (R standing for "rejected"), and laid aside.

The remainder, or all those which had stood the first proof, were then proved with the second proof; again viewed, and those which had bulged were marked R 2—thereby showing that they had withstood the first proof but failed at the second; and so on, the figure connected with the letter R denoting the proof at which it had failed.

This was termed the bulging proof, as indicating the condition at which a barrel would be rejected. When the whole of the barrels had exhibited this rejecting bulge, their order of merit of endurance was estimated as follows:

The individuals of each of the thirty-nine specimens were collected and tied together, and the relative proof which each group had sustained was estimated by means of the following principle: Seeing that the proof charges are made up of a certain number of grains of powder, the explosion of which produces stress in the barrel, and of a certain number of grains of shot, the inertia of which increases that stress, it was resolved to add together the total grains of both powder and shot, as a measure of the comparative stress which each proof charge imposed.

Each individual in a group was therefore credited as a figure of merit of endurance with the whole grains of powder and shot which it had borne, as indicated by the rejecting figure stamped upon it. The whole of the group was then so valued, by adding the proof of the individuals together, and dividing the sum by the number of individuals for the average figure of merit for the group of that kind. This system was followed throughout the thirty-nine kinds, and the table on page 10 represents the order of merit of the whole of the kinds, with the average number of grains of proof which each kind sustained without any bulging, No. 1 being the highest in merit and No. 32 the lowest, some being equal.

Further Tests.

The committee considered that it was then advisable to carry their experiments further by continuing the proof of all the individuals from the former stage with increasing charges, until every one either burst or exhibited a bulge of ·01, or ·739 of an inch.

This enlargement was measured to 1000th of an inch by an Allport's Patent Tube Measurer, adapted for the purpose. It was considered that any enlargements or bulge beyond ·01 would permit the gas to get past the wad there, and so vitiate the proof. The same methods of mixing all the barrels, weighing the charges, loading, ramming, firing, washing, cleaning, and viewing, and one by one *rejecting* every individual barrel of the whole, was repeated in the presence of the committee until the trials came to an end.

The figures of merit in this second series of experiments were attained in the same manner as formerly described, and the results are exhibited in the second table (page 11).

It is worthy of remark that in the earlier stages of proof of the barrels shown in Table I., the first bulging of most of the barrels was at from 13 to 24 inches from the breech. The larger charges, later on, attacked the barrels generally 6 or 8 inches from the breech, and, in some of the kinds, after bulging 6 or 7 thousandths, remained stationary for several proofs, eventually increasing till they attained the ·01 inch, the rejection enlargement; while others showed little sign of expansion until they collapsed in the final proof.

The committee are of opinion that this series of experiments has accurately presented the comparative elastic limit of the different kinds of material and influence of manufacture in the tubes. It is probable that the individual barrels in any group were made at the same time. The endurance of a barrel appears to depend upon a moderately high elastic limit (which prevents bulging), and a fair margin between the elastic limit and the breaking strain (which prevents bursting). If the composition of the metal and the method of manufacture is such as to yield a low elastic limit, the barrel is too soft, and bulges easily; while, if the elastic limit be unduly raised in proportion to the ultimate tenacity, the metal is deficient in ductility, and, being thus brittle, the barrel bursts. The most suitable condition appears to be attainable by judicious rolling or forging at a moderate heat, with as little reheating as is practicable. The elasticity and tenacity are affected by the purity of the metal, and by the mechanical structure set up in the compound figured irons by the various modes of twisting and laying them together. Some barrels of pure quality of material may have had their tenacity lessened by over-twisting or by mal-arrangement of structure, whilst others of more inferior material may have shown better endurance from a more judicious structure or treatment. The same remarks apply to the steels, which, under careful rolling at a moderate heat, acquire tenacity by the metal of the barrel somewhat changing from a granular or crystalline to a fibrous nature, with also a greater density, and may explain the wide difference of endurance between barrels apparently made from the same material and under the same process.

The committee are further of opinion, having regard to the dimensions of the tubes and the repeated and very great cumulative stresses which a large proportion of them have undergone, that the recent increase of stress by the proof charges in the New Rules of Proof has not been greater than was justified in the interests of the public safety.

The time and care bestowed on the work in order to arrive at just results involved twenty-two meetings of the committee. This did not include about sixteen other meetings for discussion. The whole extended over a period of two years, and it is hoped will be of value to the trade.

Dec. 31, 1890. SAMUEL B. ALLPORT, Chairman.

The board, in presenting this report to the trade, have in view the justification of the new proof charges, and have gladly placed their resources at the disposal of the committee, and charged their revenue with the expenses of the trials, so as to create a confidence in them which could hardly have been derived from the experiments of private individuals. They have also wished to promote improvement in the manufacture of sporting barrels, and they trust the results exhibited, and the considerations above offered on the purity of the materials and structural manufacture of barrels, will receive careful consideration in order to further increase the reputation which Birmingham already possesses as the source of gun-barrel manufacture of the United Kingdom.

SAMUEL B. ALLPORT,
Chairman of the Guardians of the
Birmingham, Feb. 26, 1891. Birmingham Proof House.

In looking over the two tables it will be observed that there was a very considerable difference in the cost of the barrels, the price varying from 12*s.* a pair to more than seven times that amount, or 90*s.* a pair; and, further, that the average strength by no means increased *pro rata* with the cost. It may be remarked, however, that average strength does not necessarily imply equal strength.

On examining Table I. it will be seen that, out of the thirty-nine samples, only two sets passed with equal strength in the three barrels—viz., No. 2 and No. 10 in the order of merit, the former scoring 4227 points, and the latter 3015, which respectively indicate that all three of the Whitworth tubes passed the fourth grade, and all three of the "superior barrel steel" passed the third grade. No. 1 passed with a slightly higher average than No. 2; but this appears to be due to its having passed one barrel in the fifth grade, one in the fourth, and one in the third. If the cumulative points for these three grades—viz., 5501, 4227, and 3015—be added together and divided by three, the average will be 4248. But, although this comes first in the average, we should prefer a gun with barrels of equal strength, rather than have two barrels of similar strength on the average, but one of them, in fact, more than half as strong again as the other.

In Table II. there does not appear to be any one sample which passed the whole of its three barrels in exactly the same grade; and, as the amount of variation with each is more difficult to ascertain, we regret that the official report does not state the position taken by each barrel as well as the average, because we cannot but think that the more closely the tubes approach each other in strength, the more reliance is to be placed upon the gun.

It will be observed, however, that on the average of the three barrels, the whole of the samples withstood tests far in excess of the ordinary proof—the lowest record in Table II. (which indicates a distention amounting only to the 100th part of an inch) having withstood a stress nearly six times as great as the ordinary definitive proof, while the highest records were nearly thirteen times as great as the stress of the ordinary definitive test. Hence it may be inferred that if the barrels stood such severe tests before exhibiting so small a bulge, the chance of a dangerous burst would be still more remote.

The official report shows that the position of the bulge varied with the charge which was used. When the smaller charges, extending up to about 8drs. of powder and 2oz. of shot, were employed in the first series of experiments, the bulge occurred near about the thinnest part of the barrel. In the second series, as the charges increased, the amount of shot, by its additional weight and greater amount of friction, would considerably retard the expansion of the gases, and hasten the combustion of the powder, which accordingly would exert much higher pressure at a point near to the breech; and the effect was chiefly shown where the thickness of the metal had been reduced to about ·09in., or not much more than one-third of the greatest thickness at the breech. The shot having once got into rapid motion, the tension of the gases would be quickly reduced, and the very thin parts of the barrel, further on, would be relieved of much of the strain which occurred with shot moving less rapidly and powder still in course of combustion.

In conclusion we may say that we think the Chairman of the Birmingham Proof Board, and his fellow committeemen, are to be congratulated on the completion of the onerous task which they have undertaken. The value of their services cannot, of course, be so fully understood by the amateur as by the practical gunmaker; but sportsmen may rest assured that the manufacturers of the weapons which they handle are placed in a better position for selecting the most reliable material for the construction of their guns, and that the use of them will be accompanied by a smaller amount of risk than when the material of which they were composed was, so to speak, chosen in the dark. B. P. B.—T.

STRENGTH OF GUNBARRELS.

(*Field*, March 14, 1891; vol. 77, p. 389.)

SIR,—In your article in last week's *Field* on the series of experiments carried out by the Birmingham Proof-House Board with the view of ascertaining the relative average strengths of different kinds of gunbarrels, you say: "It may be remarked that average strength does not necessarily imply equal strength; . . . and we regret that the official report does not state the position taken by each barrel as well as the average, because we cannot but think that the more closely the tubes approach each other in strength, the more reliance is to be placed on the gun." A very little consideration makes the truth of your remarks so evident that I have taken the trouble to calculate from the average figures of merit in Table I., the actual number of proofs which each barrel submitted for trial stood.

The first column in the following table shows the number of the gradually increasing proofs passed by each of the three barrels submitted for trial in each case. In two cases, where indicated, I have had to assume the misprint of one figure, since the numbers as printed cannot be resolved into any factors represented by the figures in the column of "cumulative grains."

TABLE I.

No. of Proofs passed by each of the three barrels submitted.	No. in order of merit of endurance.	Register number of group.	Average cumulative grains of powder and shot each barrel endured.	No. of Proofs passed by each of the three barrels submitted.	No. in order of merit of endurance.	Register number of group.	Average cumulative grains of powder and shot each barrel endured.
3 4 5	1	18	4248	2 2 2	21	12	1913†
4 4 4	2	38	4227	1 2 3	22	32	1946
2 4 5	3	11	3880*	5 0 0	23	33	1834
0 5 5	4	30	3667	0 2 3	24	25	1612
1 1 7	5	1	3355	1 2 2	25	27	1597
0 3 6	6	14	3285	1 2 2	25	3	1597
0 4 5	7	10	3243	0 1 3	26	8	1309
1 3 5	8	34	3142	1 1 2	27	5	1245
2 3 4	9	19	3052	1 1 2	27	17	1245
3 3 3	10	35	3015	1 1 2	27	40	1245
0 0 7	11	15	2748	1 1 1	28	21	911
2 3 3	12	39	2648	0 0 2	29	23	638
0 2 5	13	31	2471	0 1 1	30	6	607
1 1 5	14	13	2441	0 1 1	30	22	607
0 3 4	15	24	2414	0 1 1	30	27	607
1 3 3	16	2	2314	0 0 1	31	4	304
2 2 3	17	29	2280	0 0 1	31	26	304
0 2 4	18	7	2047	0 0 1	31	28	304
1 1 4	19	9	2016	0 0 0	32	20	000
0 3 3	20	16	2010				

* 3886 in the report. † 1963 in the report.

The result of these calculations shows, I think, that the Board's "No. in order of merit" is at least open to contention, as it totally neglects uniformity or regularity in strength.

Thus, judging from these experiments, one would be inclined to prefer a pair of barrels of the material twelfth in "order of merit" to a pair of No. 11 in order of merit, only one of which out of the three submitted passed the first proof On the other hand, it must be remembered that, as the first proof was almost identical with the ordinary definitive proof, and as the tubes were proved to a "rejecting" bulge, there would have been little chance of either of these two weak tubes being made into gunbarrels; and if they failed owing to "flaws," and not to inherent want of elasticity, a pair of the same material which had passed the ordinary provisional and definitive proof might perhaps be stronger than the more regular barrels twelfth in "order of merit."

One of the few things which it seems safe for the amateur to deduce from these experiments is the excellence, both as regards

uniformity and strength, of Whitworth fluid steel barrels. Only one other variety of steel at all approached it in both these qualities, viz., "superior barrel steel," No. 10 in order of merit; and it would be interesting to know by what gunmakers this is used. I have never heard of it under that name.

The fact that there is barely 20s. difference between the price of the best and the worst Damascus barrels in the rough, and that the best quality of English or foreign Damascus cost only from 25s. to 35s. a pair, will, I think, astonish most sportsmen, as gunmakers are fond of implying that they go to great expense to procure them.

Wimbledon, March 10, 1891. C. S. P.

SIR,—Some points of observation occur to me on a perusal of the report on the trials of gunbarrels just issued by the Birmingham Proof-House Board. I would first offer my thanks, as a gunmaker, for the information given to the trade, before criticising some of the results; and premise that my desire is, if possible, to improve the value of those results, both to the trade, as well as the public in general.

I note that Whitworth's steel is put down as costing 90s. per pair of tubes in the raw state. This is overstated by just 20s., the trade price being 70s. as usually bought; so that the discrepancy of cost is not so great between that and some other of the samples as would be made to appear.

It seems a matter for regret that the trials were not carried on to a final or bursting stage, which is really the one point of paramount importance to the sportsman using the gun; and how important this is, is the apparent reversal of the relative positions in order of merit, of the different samples as shown in the two published tables. The committee themselves point out that "some of the kinds, after bulging 6 or 7 thousandths of an inch, remained stationary for several proofs, eventually increasing till they attained the ·01 inch—the rejection enlargement; whilst others showed little sign of expansion until they collapsed in final proof." Would it not then have been as well to continue the proof until all specimens collapsed? For the sportsman might well be using barrels which "showed little signs of expansion," which may have passed the No. 2 table at the top of the tree, and yet which one more charge would have burst; while some others which had gone on slowly expanding were rejected and came out perhaps half way down the list, when, if kept on testing, they may have expanded but slightly larger, and seen all the other samples burst before they themselves gave way. I lay stress on this point, for let there be no mistake about this with the shooters; the first rejection—that is by viewing by the committee and proofmaster—means nothing from a practical point of view. Hundreds, aye thousands, of barrels go to second proof every year, which are returned for such a cause as here mentioned. It is probably caused by some local softness of the barrel or a local strain set up in the combustion of powder; the barrel is returned to the maker, is dressed down with the hammer, goes to proof again, stands all right, and is stamped with the proof mark, and no one is any the wiser.

Now as to rejection test, table 2 (that is ·01, or one hundredth of an inch), do readers generally recognise how small a bulge that represents. If equally spread all round the barrel, it represents as nearly as possible the substance of the note paper on which I am writing. Guns without number are constantly in use, bulged to a larger extent than this without the owner being aware of the fact, or careless of it if he is; and many guns choked on the recess principle have an enlargement nearly or quite equal to the size named.

You, Sir, in your observations last week as to the modes in which the averages are arrived at, defined a most important point. An old aphorism says, the strength of a chain is its weakest link; and so with a pair of gunbarrels. It is poor consolation to a sportsman to know that his right barrel passed, we will say, the fifth standard of excellence, when the left barrel may be only up to the third standard. As a workman, I would prefer two barrels which I knew had both passed the fourth standard: and it would materially enhance the tables published if further detailed statements were given to elucidate the stages at which each individual member of each group of barrels gave way.

I have made many combinations of figures to show me the exact position of the individual barrels of all the seven groups in the first class of table 2, but without effect. I cannot bring it nearer than 11,558 as against 11,571 published, and that supposes one barrel in the fifth and two in the eleventh classes of proof; while by another sum, assuming an error may have been made by the compiler, of a decimal in his reckoning, I get one each in the seventh, tenth, and eleventh classes respectively. In either of these cases the disparity is so great as to render the tests comparatively worthless; and I humbly ask for more light, both in details and experiments, before pronouncing a definite conclusion on the subject. F. BEESLEY.

85, Edgware-road, W., and 2, St. James's-street, S.W.

EXPERIMENTS ON STRENGTH OF GUNBARRELS.

(*Field*, June 6, 1891; vol. 77, p. 828.)

THE report of the Board of Guardians of the Birmingham Proof House (published in the *Field* of March 7, 1891) gave the details of a long series of experiments, the object of which was to test the strength of various kinds of tubes employed in the manufacture of sporting guns. These experiments were divided into two series, in the first of which the respective barrels were submitted to a succession of trials, gradually increasing in severity, until a very slight bulge (in any portion of the tube) was detected; after which the barrels were submitted to a further continuance of the increasing tests until a bulge was exhibited which amounted to the hundredth part of an inch; and the results showed that (on the average of three tubes of each group) the weakest samples withstood cumulative tests more than five times as great as the definitive proof-test ordinarily applied to guns of the same calibre, whilst the strongest samples withstood such cumulative tests until they mounted up to more than twelve times the charge used in the ordinary proof.

It was remarked, however, in the correspondence which ensued on the publication of the official report, that the distention of a barrel by the hundredth part of an inch is so trifling an enlargement of the bore that a sportsman might shoot for years with a gun so distended without being aware of the existence of the bulge. And it was suggested that the experiments should be further proceeded with in order to ascertain what the barrels would eventually withstand before actually bursting.

The Birmingham Proof Board, however, were indisposed to increase the serious expenditure of time already devoted to the experiments (which had extended over a period of about two years), and they were of opinion that it would have enlarged and complicated their report impracticably to have described the individual behaviour of every barrel, and to have stated in detail all the circumstances of the many hundreds of trials which they carried out.

It occurred to us, however, that, although the Proof House authorities could not undertake further operations on the large scale which had characterised their original experiments, it might yet prove of interest to the sportsman, and possibly be of some service also to the gun trade, if we were to try certain additional experiments on a more restricted scale. We accordingly resolved to test a few tubes up to bursting point, and to do so in such a manner as would, we hoped, serve to settle some of the moot points which have frequently been discussed, and which have occasionally led to the expression of very strong opinions, without, however, eliciting any definite evidence to prove that those opinions were based on a reliable foundation.

Among the unsettled questions which we thought might be capable of receiving further elucidation by means of additional experiments were—(1) whether there is any wide margin of difference between the bulging point, which entails the rejection of gunbarrels when submitted to the official proof, and the bursting point, which might place the user of the gun in a position of considerable danger, especially if the fracture occurred in close proximity to the breech; and (2) which of the two kinds of material chiefly used in the manufacture of gunbarrels—viz., Steel and Damascus—would exhibit the greatest degree of toughness, or power of resisting a dangerous fracture, such as would be likely to inflict injury on the user of the gun. It may be readily imagined, for instance, that a hard steel barrel would be able to withstand a more severe strain than Damascus before it exhibited a bulge amounting to the hundredth part of an inch, and yet that the steel barrel might eventually prove to be more risky to handle, because the Damascus might be able to withstand a great increase of strain with no worse effect than a more pronounced bulge, whereas a similar increase of strain might possibly shiver into fragments a barrel made of harder and more brittle material.

Another matter for determination was whether the great heat to which barrels are subjected during the brasing process is or is not necessarily a cause of great deterioration in their strength—a question which was not in any way met by the Birmingham experiments, as the whole of the tubes there tested were unbrazed. We therefore resolved that, of the two pairs of barrels which we submitted to trial, one tube of each kind should have a steel lump properly brazed to it, and these brazed barrels should be tested in comparison with unbrazed barrels of the same materials, and under exactly the same conditions.

In choosing barrels for the trial, we had intended to select the two kinds which stand first and second in Table II. of the Birmingham Proof Board (as previously published—see page 11), where they took equal rank in the second series of tests, in which a bulge of a hundredth part of an inch caused the rejection of the barrel. The material of the barrels which stood first in the list (the number of the sample being Group 30) is described as "English steel, Siemens-Martin process, rolled from a hollow mould; slightly harder than No. 29 group." The softer sample of steel (No. 29 group) had

exhibited a bulge with little more than half the stress withstood by Group 30; and the further testing of the hardened barrels, and the carrying of the experiments up to bursting point, would have the effect of showing whether the ability to withstand bulging, obtained by the hardening of the steel, had been acquired at the expense of increased brittleness and liability to fracture; and there would also be an opportunity of ascertaining whether this hardened steel would be more especially affected by the process of brazing.

As regards the Damascus (machine-forged) barrels, which stood second in Table II. of the Birmingham Proof Board, our intention to use them was frustrated through our inability to obtain specimens of these tubes for trial; their manufacturers were content with the laurels they had already gained in the official trials. Consequently we used instead a pair of the best hand-forged English Damascus barrels, which did not come so near to the front in the bulging trial, but nevertheless have the reputation in the trade of being the best Damascus barrels made. In this instance, likewise, one barrel had a steel lump brazed on, and the other was unbrazed.

In our previous article we gave (see page 9) a woodcut showing the thickness of metal at different parts of the barrel, and we also stated that the tubes were bored perfectly cylindrical inside; consequently they were not chambered. But the cutting away of metal, in chambering a gun for the paper cartridge case, must necessarily affect the strength of the barrels; so, in order to place our experimental barrels as nearly as possible on the same footing as those of ordinary guns, we had them chambered in the usual way. But in testing the tubes we did not make use of cartridge cases, as those for which the barrels were chambered would necessarily be too short to hold the larger charges used in the experiments; so we had a fixed breech (with a touch-hole of $\frac{1}{15}$in. diameter) screwed into the barrel, and loaded from the muzzle accordingly; and, there being thus no paper cylinder to take the place of the metal removed in chambering, it may be assumed that the strain on the chamber was somewhat more severe than it would have been if paper cases had been available. We may add that the barrels (which were 30in. long) were not of unusual thickness, but were such as would, when completed with the usual ribs, action, stock, &c., have made double-barrelled 12-bores weighing about 6$\frac{3}{4}$lb. each.

Generally speaking, when a gun bursts in a sportsman's hands, he does not run any considerable risk unless the fracture occurs near to the breech. We therefore thought it desirable in carrying out these tests to obtain a very high powder pressure at that part of the barrel where a breakage would be most dangerous. An increase in the charge of shot is well-known to cause a considerable increase in the amount of force developed from the same charge of powder; and, in order to produce this increase of strain to the fullest extent possible, we resolved, while adopting the regulation charge of powder used in the official proof of 12-bore guns (viz., 6$\frac{1}{2}$drs.) we would commence with 2oz. of No. 6 shot, and increase the quantity uniformly by additions of half an ounce each. One 11$\frac{3}{4}$ gauge *Field* wad, with a $\frac{3}{8}$in. felt of 12 gauge, was placed between powder and shot, and a card wad over the shot. The barrels were cleaned and slightly oiled after every round.

The following table will show the actual charges used for the successive tests (the powder employed was Curtis and Harvey's No. 4 Treble Strong), and under the respective headings there is placed

Fig. 1.

Fig. 2

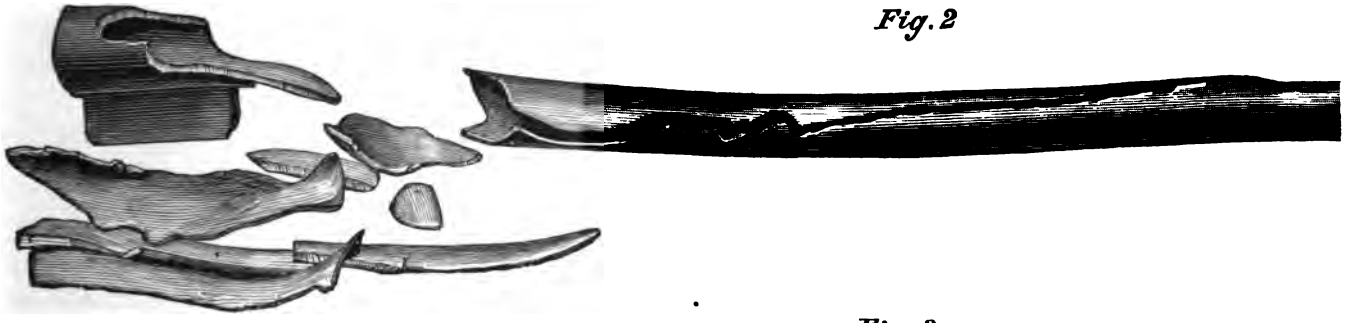


Fig. 3.

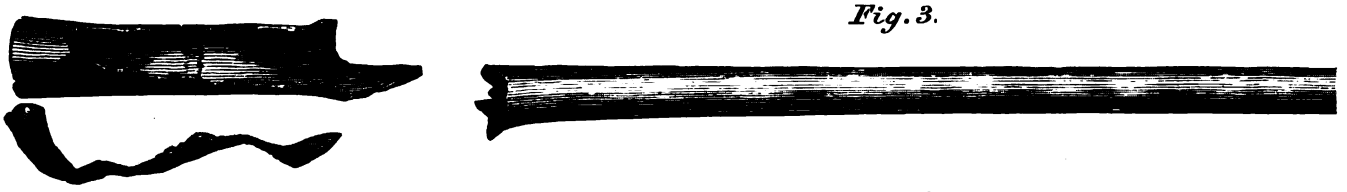
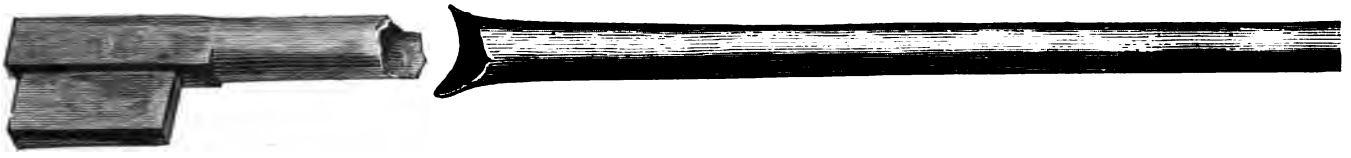


Fig. 4.



a figure (1) to indicate that the trial alluded to was satisfactorily passed by the barrel in question:

Number of Test.	Charge. Powder.	Shot.	Steel Barrels. Unbrazed.	Steel Barrels. Brazed.	Damascus Barrels. Unbrazed.	Damascus Barrels. Brazed.
1	6¼drs.	2oz.	1	1	1	1
2	6¼drs.	2¼oz.	1	1	1	1
3	6¼drs.	3oz.	1	1	1	1
4	6¼drs.	3¼oz.	1	1	1	1
5	6¼drs.	4oz.	1	1	1	1
6	6¼drs.	4¼oz.	1	1	1	1
7	6¼drs.	5oz.	1	1	1	1
8	6¼drs.	5¼oz.	1	1	1	1
9	6¼drs.	6oz.	1	1	1	1
10	6¼drs.	6¼oz.	1	1	1	1
11	6¼drs.	7oz.	1	1	1	1
12	6¼drs.	7¼oz.	1	1	1	1
13	6¼drs.	8oz.	1	1	1	1
14	6¼drs.	8¼oz.	1	1	1	1
15	6¼drs.	9oz.	1	1	1	1
16	6¼drs.	9¼oz.	1	1	1	1
17	6¼drs.	10oz.	1	1	1	1
18	6¼drs.	10¼oz.	1	1	1	1
19	6¼drs.	11oz.	1	1	1	1
20	6¼drs.	11¼oz.	1	1	1	1

It will here be observed that each of the four barrels withstood twenty successive rounds, with as much powder as is used in the definitive proof test, but with considerably increased amounts of shot. In the statutory proof-charge the weight of shot used is 1⅝oz., whereas here it was increased from 2oz. to 11¼oz., or an average of 6¾oz.; yet neither of the four barrels appeared to the eye to be much the worse for the severe strains encountered. We did not test them with a micrometer gauge to ascertain whether any difference in thousandths or hundredths of an inch had occurred, as that process had already been carried out in the Birmingham Proof-House trials.

In round No. 21, with 6½drs. and 12oz., the shot stuck in the barrel, the powder not being sufficient to force out the pellets, though driving them for a distance of several inches, when they became tightly jammed, and the powder gases gradually exhausted themselves by "fizzing" out of the touch-hole. The same thing happened with all four barrels, and the compacted charges of shot had to be picked out by a tool in each instance, after which the barrels were cleaned and oiled as before. The powder-charge was thereupon increased to 7drs., the shot remaining at 12oz., but again there was a failure to eject the charge; and the same thing recurred with 7½drs. and 8drs. of powder, and the charge had in each instance to be picked out. With 8½drs., however, the shot was duly expelled; and the proceedings went on as follows—the cypher (0) indicating those rounds in which the charge of shot stuck in the barrel.

Number of Test.	Charge. Powder.	Shot.	Steel Barrels. Unbrazed.	Steel Barrels. Brazed.	Damascus Barrels. Unbrazed.	Damascus Barrels. Brazed.
21	6½drs.	12oz.	0	0	0	0
22	7drs.	12oz.	0	0	0	0
23	7½drs.	12oz.	0	0	0	0
24	8drs.	12oz.	0	0	0	0
25	8½drs.	12oz.	1	1	1	1
26	9drs.	12oz.	1	1	1	1
27	9½drs.	12oz.	1	1	1	1
28	10drs.	12oz.	1	1	1	1
29	10½drs.	12oz.	1	1	1	burst
30	11drs.	12oz.	1	1	burst	—
31	11½drs.	12oz.	1	1	—	—
32	12drs.	12oz.	1	1	—	—
33	12½drs.	12oz.	1	1	—	—
34	13drs.	12oz.	1	1	—	—
35	13½drs.	12oz.	1	1	—	—
36	14drs.	12oz.	1	1	—	—
37	14½drs.	12oz.	1	1	—	—
38	15drs.	12oz.	1	1	—	—
39	15½drs.	12oz.	1	1	—	—
40	16drs.	12oz.	burst	burst	—	—

The appearance of the respective barrels, after bursting, will be seen by reference to the illustrations given on page 15, which, in order to bring them within the width of the page, are photographed to a scale of about one-third the original dimensions as regards size of barrel, besides being reduced to a length equivalent to about 20in., but including all the fractured portion of the barrel.

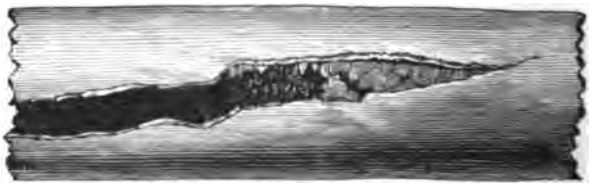
Fig. 1 represents the remains of the unbrazed barrel of Siemens-Martin steel, which burst with test No. 40, when the charge used was 16drs. of powder and 12oz. of shot. This barrel first exhibited signs of distress with trial No. 26, when the charge was 9drs. of powder and 12oz. of shot, the tube then showing a slight bulge at 7in. from the breech, and being somewhat rivelled and bent near the muzzle; nevertheless, it underwent thirteen more tests before the actual fracture occurred.

Fig. 2 represents a barrel similar in character to Fig. 1, the only difference being that it had undergone the brazing process. This barrel behaved almost exactly the same as the unbrazed tube, bulging with the same test (No. 26), at 7½in. from the breech; and bursting with test No. 40. With charges exceeding 11½drs. of powder and 12oz. of shot, both of these steel barrels became so much bent that they had to be straightened in order to pass the loading rod down them; and such distortions of the tube must considerably have increased the resistance to the passage of the shot in subsequent rounds.

Fig. 3 shows the unbrazed Damascus barrel. With this the first indication of distress was seen after firing test No. 23, when the charge was 7½drs. of powder and 12oz. of shot; it was then somewhat rivelled and bent. In the next round the barrel commenced to bulge at 6in. from the breech; but it held on for six more trials, and collapsed at test No. 30, with 11drs. of powder and 12oz. of shot.

Fig. 4 represents a barrel of the same kind as No. 3, the only difference being that it was brazed. It behaved in a very similar way to the unbrazed barrel, and burst one round earlier.

In every case, when the burst occurred, the shot remained in the barrel. The woodcut here given shows (full size) a compacted mass of pellets as left in the barrel after the breakage; the shot were jammed into an apparently solid mass, and, though not actually welded together, every pellet was crushed utterly out of shape.



TWELVE OUNCES OF SHOT IMPACTED IN 12-BORE BARREL.

These experiments serve to show what a very large margin of strength there is in a good gunbarrel, when ordinary charges are used. They also tend to prove that the brazing process (if properly carried out) does not injure the metal to any appreciable extent.

It has frequently been alleged, by opponents of the proof test, that, although the barrels may pass through the proof without any apparent injury, yet the large charge strains the metal to such an extent that the barrels are likely to burst afterwards when used with ordinary charges.

The fallacy of this argument appears obvious when the fact is taken into consideration that the barrels which gave way earliest under these tests had withstood the strains of nearly thirty successive trials, the first of which was rather more severe than the definitive proof-charge, and the average of the whole was about four times as great as the regulation proof; while the steel barrels were tested forty times, with charges averaging nearly five times as much as the ordinary proof-charge.

Taking the cumulative grain test, as calculated in the Birmingham experiments, the strains undergone by each of the two steel barrels were rather over 190 times as great as that of the definitive proof test; and those of the Damascus were rather over 120 times the definitive proof in the case of the barrel that had undergone the brazing process, and nearly 130 times in the barrel that was not brazed. So that, although the steel barrels showed the greater amount of endurance, the strength of the Damascus was so much in excess of all ordinary requirements that no fear need be felt of their giving way when the work is properly done.

P.—T.

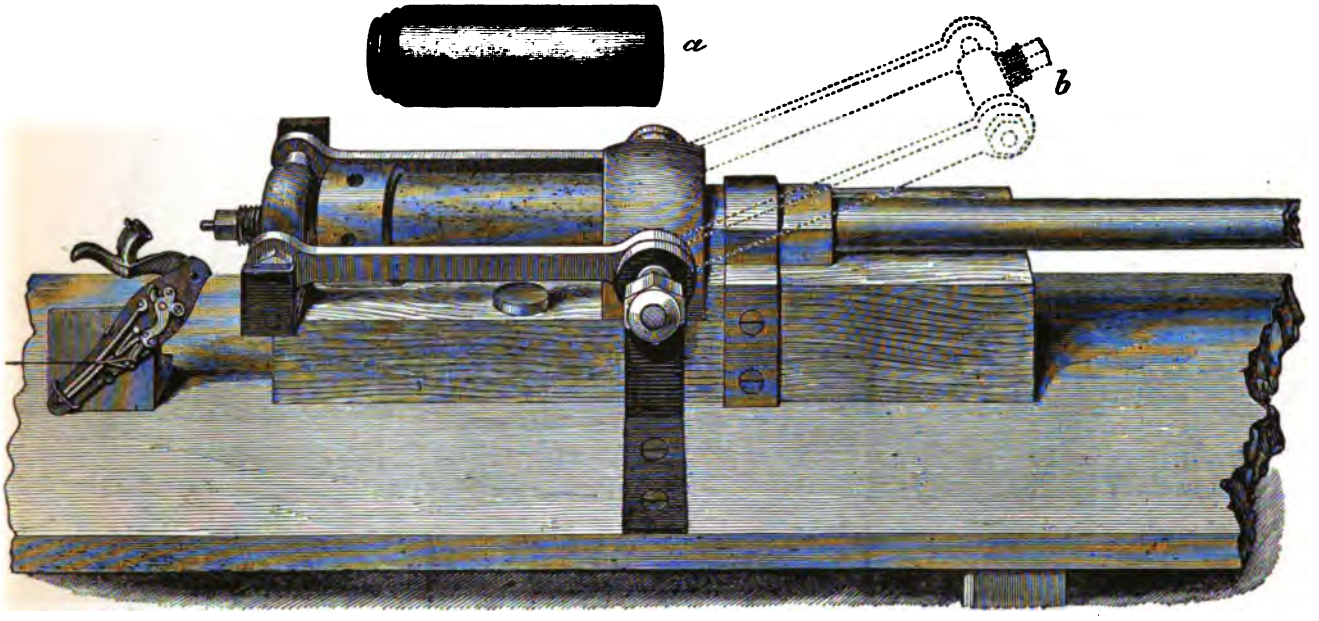
TESTS OF STRENGTH IN GUNPOWDERS.

(*Fields* of 1884; vol. 63, pp. 124, 126, 366. Originally summarised for *Rural Almanac* of 1885.)

IN the course of the shooting season of 1883-4 many complaints were made with respect to guns being burst or damaged by the nitro-compounds known as E.C. and Schultze gunpowders; and widely conflicting opinions were expressed as to the immediate cause of the untoward results. With the view of tracing, if possible, how it was that, while many persons were constantly using the respective explosives, and were very well pleased with them, others found their use attended by most unpleasant consequences, the Editor of the *Field* determined to carry out an exhaustive series of experiments. He accordingly procured numerous samples of E.C. and Schultze powder, some being obtained by the purchase of unopened canisters through the trade, and others being loaded cartridges sent to him for examination by readers of the *Field*.

The samples of powder were tested chemically by analysis, and experimentally by the firing of charges; cartridges were unloaded, and the contents weighed, to ascertain whether the actual quantities agreed with their nominal charges; the nature of the loading was black powder; but we did not proceed to make any experiments to ascertain the effect of such careless or injudicious treatment of it as might possibly be adopted by the sportsman. Subsequently, in consequence of a limited number of accidents which came to our knowledge, we suggested to our readers that, under certain conditions of 'detonation,' drying, &c., it was not to be considered safe; but what those conditions are we were unable to ascertain. Then came the production of the E.C. powder in 1882, which we at once pronounced to be at least equal to Schultze powder in shooting qualities; but as to its comparative freedom from danger, we still had no guide." He then proceeds to describe the new powder pressure gauge used by him in carrying out the experiments of 1884.

The illustration represents the apparatus at about one-fourth of its actual size. The letter *a* shows a cylinder 5½in. long, with chamber and bore exactly similar to those of a 12-bore gun, except that, instead of being of the thickness and material of an ordinary gunbarrel, it is made of lead, and the walls are half an inch thick. This lead cylinder is inserted in the machine by throwing back the steel breech and side straps indicated by the dotted lines marked *b*. The cylinder is first loaded with an ordinary cartridge, over which is screwed a steel breech, perforated by a hole for a striker, and furnished with a central plug to back up the base of the cartridge. It is thus a short leaden gun, with ordinary chamber and bore, connected by the usual cone. It is, of course, possible to explode this by itself; but, in order to make the conditions assimilate to those presented by an ordinary gun, the leaden cylinder (*a*) is attached to a gunbarrel, as shown in the woodcut, by means of a strong gun-metal cap, into which it is dropped, the lead fitting into the gun-metal so as to prevent any escape of gas. After dropping in the lead cylinder, the side straps, shown in dotted lines, are turned down, and a square-headed screw in the centre of the cross-piece is turned till it firmly backs up the steel cap already mentioned. The striker is then introduced, and the lock cocked. Thus there is a gun composed partly of lead and partly of iron, loaded and discharged exactly as if it were in the hands of a sportsman, but with an expanding leaden breech, measuring the force exerted by the charge.



LEAD CYLINDER PRESSURE-GAUGE.

a The Lead Cylinder. *b* The Breech, turned up for insertion.

examined, and the strength of the caps tested. Furthermore, as many sportsmen are in the habit of drying their cartridges before use, or of constantly keeping them in warm closets, experiments were carried out to try the explosive force of equal charges of the same powder in a dried and an undried condition; and likewise to ascertain the effect of putting a pinch of black powder over the cap before proceeding to load the cartridge with E.C. or Schultze.

The investigation extended over several months, and proved that the accidents complained of were due to various and very different causes. Careless loading was one cause, the charge of powder put into the cartridges being occasionally very much larger than was ordered; difference in strength of caps was another cause. There was also an increase of explosive force produced by putting black powder as a priming in the cartridge, to give more rapid ignition to the nitro-compounds.

The Editor, in reporting on the result of his experiments, says: "The former of these powders (Schultze) we had ourselves tried with regard to its safety in 1878-9, and had arrived at the conclusion, after fully five thousand experiments with a powder-gauge constructed for our use, that, *as sent out by the company*, it was quite as safe as

There are two methods by which the dilatation can be measured—first, by its greatest diameter as compared with that of the original chamber; and, secondly, by its increased cubical capacity. Both of these measurements were taken in each test, and are given in the *Fields* of 1884, but we prefer the linear expansion, as being the indica-

tion of the greatest strain, which is always taken as the proper measure of any material, whereas the cubical capacity shows only the average increase. We will now proceed to show the force exerted by the three powders under consideration—viz., Curtis and Harvey's No. 4; Schultze powder, which varied very little in the several samples; and E.C. powder in its weakest and strongest conditions—the latter, as will be seen, varying considerably in explosive force.

Commencing with black powder, the result is indicated in Fig. 1, which is an exact representation of a section of the lead cylinder in which a charge of 3drs. of C. & H. No. 4 powder has been exploded

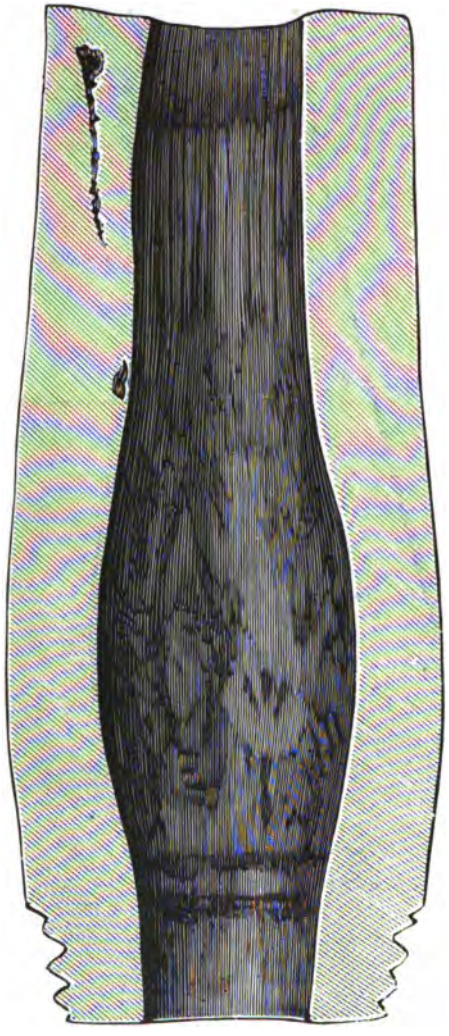


FIG. 1.—3DRS. C. & H. No. 4.

with 1⅛oz. No. 5 hard shot, using two *Field* wads over the powder and a *Field* wad over the shot—which latter, though not giving such good shooting as a thin card wad, is used by some sportsmen, and as it gives a higher pressure with the three powders, it was selected in all these experiments, because the object was to ascertain the greatest amount of pressure likely to be exerted. With this the chamber was enlarged from ·80in. (its original diameter) to 1·29in., its diameter after the cartridge was fired—*i.e.*, an increase of ·49in.

Fig. 3, on p. 19, shows the result of firing 42grs. Schultze powder with the same wads as used above, and without more pressure in loading than simply to seat the wads. Here the explosive force is much less than with the black powder, the chamber being only enlarged ·17in. It will be seen that the enlargement is pretty uniform from the base of the chamber to the cone, beyond which it does not perceptibly extend.

Fig. 5, p. 20, exhibits the force of 42grs. of the mildest sample of E. C. examined, though sufficiently strong to give good results at the target. In loading this powder the full pressure of the arm was exerted. Here the force was a little more than that of the Schultze powder, the increased expansion in the cylinder being 25in.

In Fig. 7 (page 21), with 42grs. of the strong E.C., is indicated an explosive force nearly the same as that of the black powder (see Fig. 1), and giving excellent shooting, slightly superior to that shown

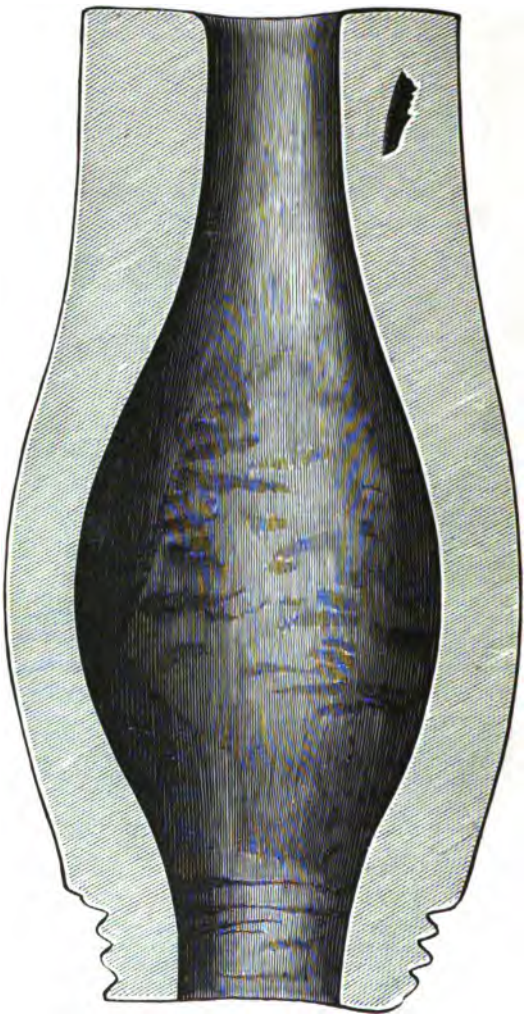


FIG. 2.—7DRS. C. & H. No. 4.

in Fig. 5, but not to any great extent. The increase of diameter in Fig. 7 was ·43in.

EFFECT OF DRYING THESE POWDERS.

We now come to the consideration of the effect of drying on these three powders, as carried out to the full extent of depriving them entirely of water, which was effected by heating them in a hot-water bath. These powders, however, were not fired when in a heated condition, but were allowed to cool, and were kept a day or more before use, being shut up in air-tight jars in the interval, so as to preclude any re-absorption of moisture.

In their normal condition, as sold to the public in canisters, black

powder contains about 1 per cent., Schultze 3 per cent., and E.C. 2½ per cent. of water; and in such condition they appear to exert the explosive force required by the sportsman without danger to him.

When a charge of black powder, dried as above mentioned, was tested in the apparatus, no increased expansion in the lead cylinder was observable; but when the other two powders thus dried were exploded, there was a remarkable development in the force. The dried Schultze, in particular, exhibited an enormous increase of expansion, as seen in Fig. 4. Here, instead of the slight dilatation shown by an equal charge of undried Schultze in Fig. 3, we have a large bulbous cavity, measuring 1·89in. in its greatest diameter, being an increase of 1·09in., or about six times the increase given by the undried powder.

With the E.C., even the stronger sample, the increase, although considerable, was not so great as with the Schultze. Fig. 6 shows the expansion exhibited by the cylinder loaded with 42grs. of mild E.C. powder, dried, which produced an increase of ·65in., or nearly three times the expansion shown by the undried charge. In Fig. 8 we have a representation of the force exhibited by the stronger sample of E.C. powder, which gave an increase of ·99in. So that, although this strong sample of E.C. expanded the lead more than twice as much as the Schultze, when both were in an undried condition, yet there was not very much difference between them when dried, and Schultze was then the more violent of the two.

From these experiments (which were repeated about a dozen times in each case) it may undoubtedly be concluded that both Schultze and E.C. powders (as then made) might be dried in bulk until they became absolutely dangerous.

It was stated in the *Field* that the powders had been dried at a temperature of 230°; but this was an error, arising out of the fact that some empty cartridge cases were dried at that temperature. Mr. Woodland Toms, F.I.C., F.C.S., who carried out the chemical investigation, and who carefully dried, at definite temperatures, the various samples experimented on, thus corrected the mis-statement: "Some of your correspondents are under a misapprehension as to the temperature at which the powders were dried for your experiments. In the earlier experiments with lead cylinders, 150° Fahr. (the temperature advised by the Schultze Company) was used for drying both kinds of powder; afterwards the experiments were repeated at 212° (the E.C. Company's maximum); but in no case was the powder heated to a higher temperature than that of boiling water.

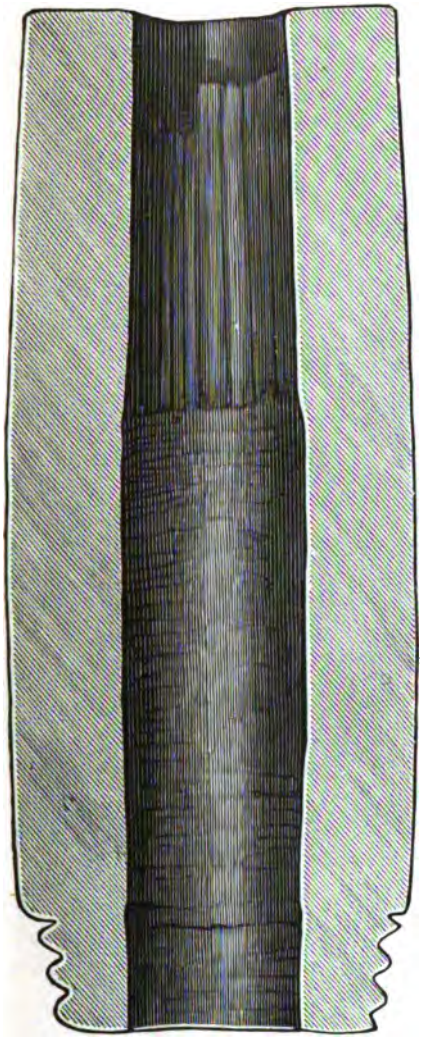


FIG. 3.—42 GRAINS UNDRIED.

FIG. 4.—SAME CHARGE DRIED.

SCHULTZE POWDER (1884).

It was the paper cases alone that, for some special experiments, were dried separately at 230° Fahr."

It having been proved that danger was produced by drying these nitro-compounds, the Editor proceeded to ascertain how far the danger was likely to be developed under ordinary circumstances; and these are the answers he gave to questions which he set himself to determine:

Question 1. Is the sportsman likely to dry his powder in bulk so completely as was here done, with the results shown in Figs. 4 and 8? if not, what is the result of the drying likely to be carried out by him? this increased force? With respect to this, the Editor found that cartridges, whether of Schultze or E.C., if dried for three or four days in a dry closet heated only to 80° Fahr., would exhibit as great a pressure as that shown in Fig. 4, if loaded with Schultze, or as in Fig. 8, if with E.C. Such was the case with a lot of loaded cartridges which had been dried by a correspondent as described in the annexed letter:

SIR,—With reference to your experiments upon sporting powders, it has struck me that the cartridges which I now forward may be usefully tried, inasmuch as they will afford a test of the effect of dry, warm storage under ordinary conditions. Many sportsmen put away the cartridges, as I have done, in the closet of a dry room, which has the additional heat of a flue passing up one of the walls of the same.

The accompanying six cartridges were purchased at the end of last November from Cogswell and Harrison. The instructions were to load them with Schultze powder equivalent to a charge of 3drs. of black powder. They have in them 1¼oz. of No. 5 chilled shot.

The temperature of the closet varies from 60° to 70°, and they have been in it for nearly three months.

W. B. GALBRAITH.

91, Finchley-road, N.W.

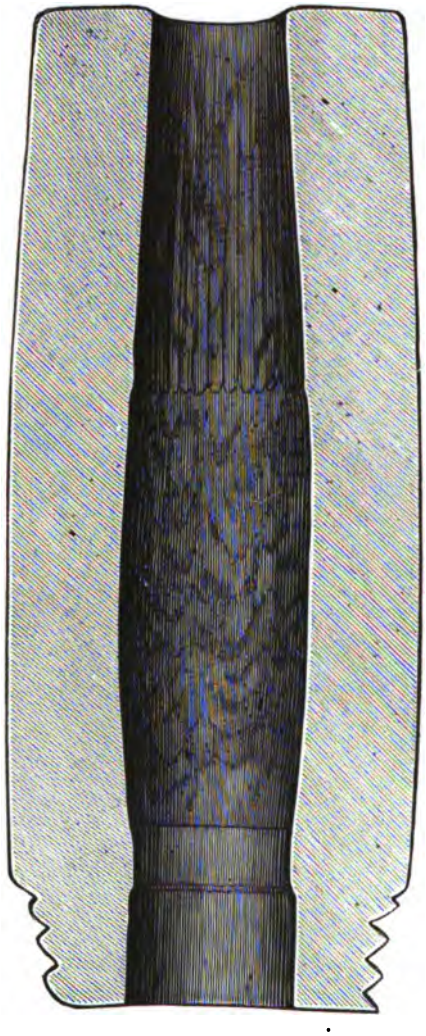


FIG. 5.—42 GRAINS OF E.C. (MILD SAMPLE) UNDRIED.

FIG. 6.—SAME CHARGE DRIED.

To the first question we may reply in the negative; but we have ascertained that many of those who load their own cartridges have been in the habit of drying their powder in bulk in the way long adopted for black powder—*i.e.*, by placing the canister in boiling water, while others have used ovens at varying high temperatures. The Editor found that the effect of this was practically the same; for powder thus dried for two or three hours developed the same force as shown in the above-mentioned diagrams. Even when the powder was dried in bulk at only 80° Fahr., for eight hours, the same effect was produced.

Secondly. To what extent will drying the loaded cartridge develop

In this instance the force developed was as nearly as may be that shown in Fig. 4 (page 19).

Thirdly. With regard to the comparative effect of priming on the two powders, the Editor found, after carefully repeated experiments, that both powders are greatly increased in force by the adoption of the plan.

The caps used were tested in the way employed by Mr. Reid at Stowmarket [then the gunpowder works of the E.C. Company]. It consists in making saw-cuts at intervals of an inch across an open brass tube, fitting loosely in a gunbarrel loaded with an empty case, and when the cap is exploded the number of guncotton threads burnt indicates the strength of the fulminate. From experiments made with this cap tester, it was found that the average cap burned from seven to eight threads, while the strong caps used in these experiments would burn from sixteen to eighteen.

One of the most common practices with sportsmen using both Schultze and E.C. powders, was to substitute a few grains of black powder for an equal bulk of whichever nitro-compound was used—the object being to avoid the "hang-fires" which formerly used to prevail. This defect is now avoided by Messrs. Eley and other makers, who furnish cases for each kind of powder; but the practice of priming was very common, and led to the development of a greatly increased force. This is still further augmented if an unusually strong cap is employed, which was for some time done for the same purpose, but the practice is now generally abandoned, owing to the danger attending it.

Among the experiments were some in which both these plans were adopted. The undried mild E.C. powder (see Fig. 5) was primed with a few grains of black, and fired with a strong cap, whereupon the force was considerably increased, the expansion being greater than with the dried but unprimed charge (Fig. 6), and nearly as great as in the dried strong powder (Fig. 8). A similar experiment was tried with a dry charge of mild E.C. and the result was very nearly the same as with the undried.

Having ascertained that great increase of force is developed—first, by drying; secondly, by priming with black powder; and, thirdly, by using strong caps, the next thing to be done was to ascertain what quantity of black powder would develop an equal force. This was, of course, a very simple process, as it was only necessary to go on increasing the charge till it produced a similar effect on the leaden cylinder.

Accordingly, beginning with 3drs. C. & H. No. 4, and gradually

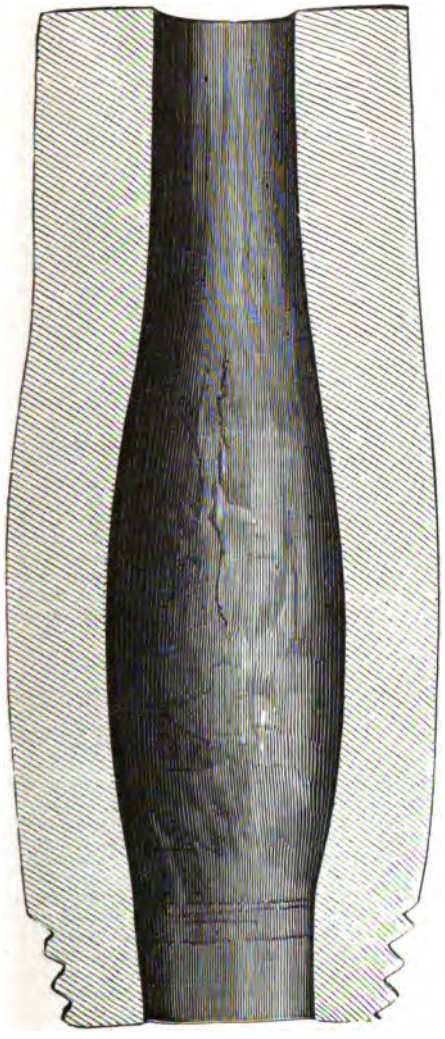


FIG. 7.—42 GRAINS OF E.C. (STRONG SAMPLE) UNDRIED.

FIG. 8.—SAME CHARGE DRIED.

increasing the charge, the following results were obtained, the shot being in each case the proof charge—1⅛oz.:

C. & H. No. 4.	Increased diameter of lead.
3 drams (see Fig. 1, page 18)	0·49
4 ,,	0·60
5 ,,	0·75
6 ,,	0·87
7 ,, (see Fig. 2, page 18)	1·08
8 ,,	1·30
9 ,,	burst

In comparison with these may be put the results obtained from the nitro-compounds, the charge being the same with both (viz., 42grs.):

	Increased diameter of lead.
Schultze, undried (see Fig. 3, p. 19)	0·17
E. C. (mild), undried (see Fig. 5, p. 20)	0·25
E. C. (strong), undried (see Fig. 7, p. 21)	0·43
E. C. (mild), dried (see Fig. 6, p. 20)	0·65
E. C. (strong), dried (see Fig. 8, p. 21)	0·99
Schultze, dried (see Fig. 4, p. 19)	1·09

Comparing these results, it appears that 42grs. of mild E.C. powder (equal in measure to 3drs. of black) developed, when dried, a force equal to about 4½drs. of C. & H. No. 4; while the same charge of E.C., when primed, and whether dried or undried, exerted a force equal to about 6drs. of the black powder. A similar charge of undried Schultze, when primed, was as nearly as may be equal to 5drs. of the black powder. The same charge of Schultze, dried, but not primed, was equal to 7drs. of C. & H. No. 4—which, being a much stronger powder than that used at the proof-houses, may be considered to far exceed the pressure of the "definitive proof-charge." A larger charge of Schultze (viz., 46grs.), when dried, showed a force equal to 8drs. of black powder, but still the lead did not burst. This was accomplished by 9drs. of C. & H. No. 4; and the same result was obtained by 54grs. of Schultze when dried.

An event which occurred during the experiments may explain some of the accidents which have been described when the barrel has burst about its middle. It happened that the Editor had in his possession a cartridge loaded by him in 1879, and marked with its load of Schultze powder. This having lain in a table drawer in the interval, he determined to test it in the machine. The consequence was a very mild report, but strong enough to indicate that it was more than a misfire. He therefore examined the barrel, and found *the whole charge of shot resting about its middle*, having apparently allowed some part of the gas to pass by its sides, and thus cause the slight report he had heard. Now, this with a damp cartridge might easily occur, and, a second cartridge being fired without removing the obstruction, a burst in the middle portion of the barrel might be the result.

It has already been stated that some of the "accidents" were the result of improper loading; and the following observations, by Mr. Woodland Toms, in his "Chemical Report on the E.C. and Schultze Gunpowders" (*Field*, April 19, 1884), will show how gross must have been the carelessness, in some cases, for the cartridges to be loaded with such excessive charges:

> A study of the details, taken in conjunction with your own experiments, does not sustain the view that either of these powders, as now manufactured, need be regarded as dangerous *per se*, if the directions given on the packages be duly adhered to. Most of the accidents seem to be attributable to causes that are easily preventible, if once the necessity of observing the directions is fully understood.
>
> Thus, 42grs. of these powders produce results comparing favourably, in propelling power, with the normal charge of black powder weighing twice as much. There is no need, therefore, to exceed these proportions for a 12-bore; and, considering that these nitro-compounds, from the rapidity with which they become resolved into gaseous products, are liable to exert a much higher momentary strain on the breech, it is also undesirable to use larger charges.
>
> On examining, however, the samples of cartridges represented to be "dangerous," three at least owe their perilous properties to this cause. One was a "Perfect" brass 12-bore cartridge charged with Schultze, and loaded with no less than 65grs. of this powder. It is not surprising, therefore, that the gun burst. In two instances of injury to the gun with E.C. powder, the cartridges were loaded with 51grs., which is also an excessive charge.
>
> Another cause that greatly affects the violence of the explosion of the powders is the strength of the caps employed. On examining by the cap-tester my small assortment of "dangerous cartridges," two of these batches were found to be provided with the dangerous caps.
>
> A fifth dangerous cartridge was loaded with E.C., primed with black powder, and it is noteworthy as the only specimen so loaded out of over thirty batches opened. It was a 20-bore, a class of guns apparently rather liable to fail with excessive strain. It is interesting to observe that your independent observation as to the increased explosive force produced by E.C. when primed with black powder virtually explains the cause of this accident, especially when connected with the charge of 42grs., which is large for a 20-bore.

In another instance, not included above, a 16-bore gun was burst, and it was found that the gunmaker had loaded the brass "Perfect" cases with 56 grains of Schultze, instead of 38 or 40 grains, which would be about the normal charge for a 16-bore.

Since the foregoing experiments were carried out, there has been an unusually hot and dry summer, during which many pigeon-shooters, who had previously been accustomed to use Schultze powder, changed it for E.C., as they found the former shook or damaged their guns to an extent they had not previously experienced. It seems probable that this result may have been due to the very dry condition of the atmosphere during the height of the pigeon-shooting season, and to the cartridges being loaded with powder containing less than the usual amount of moisture. Schultze, in its normal condition, not only contains rather more moisture than E.C., but it parts with its moisture more rapidly in a dry atmosphere, as the E.C. grains have a kind of varnish on the surface which the Schultze powder does not possess. [The Schultze powder now has such a "varnish," as will be seen by reference to the extract from Her Majesty's Inspectors of Explosives, quoted on page 23.]

It has been inferred by some persons, from seeing the statement that E.C. and Schultze powders are dangerous if dried, that necessarily they must be dangerous in hot climates; but, although such might be the case if the air were very dry as well as very hot, it would not be the case in all hot countries, for in some the atmosphere is much damper than in colder localities; and mere warmth does not appear to materially affect the explosive force of these nitro-compounds unless it has the effect of removing the moisture. As pointed out above, these powders were rendered dangerous when the moisture was abstracted in a dry closet only heated to a temperature of from 60° to 70°. On the other hand, in the course of these experiments, loaded cartridges were submitted to considerably higher temperatures for periods of time that sufficed to heat the powder, but not to dry it; and although these cartridges were fired in a heated condition, there was not sufficient difference in the explosive force to show any material increase in the expansion of the lead cylinder.

It appears obvious, therefore, that the increase of force is due to the dryness of the powder, and not to its warmth: the less the amount of moisture, the more rapid the combustion. And this is in accordance with experience with other combustibles; for thoroughly dry wood will burn rapidly although it may never have been submitted to a high temperature before ignition; whereas damp wood may be made too hot to hold, and yet will burn very slowly, if it ignites at all.

W.—T.

RESULTS OF EXPERIMENTS WITH GUNPOWDERS.

(*Fields*, 1885; vol. 65, pp. 171, 181, 216, 252, 285, 346, 490. Originally summarised for *Rural Almanac* of 1886.)

We have previously given an account of a series of experiments which had been carried out, in 1884, by the Editor of the *Field*, with a view to ascertain the origin of a number of accidents, of a more or less serious character, that had occurred in the use of Schultze and E.C. powders; and it will probably be remembered that it was ascertained that several causes had been in operation which were likely to produce the damage to barrels and actions then so much complained of. Perhaps the most fruitful source of mischief was that of drying the powder; for whereas, with the old black mixture, it had become an axiom that to "keep your powder dry" was an essentiality of the highest consideration, there was a vast difference in the effects produced when the same practice was carried out to an equal extent with the nitro-compounds. The percentage of moisture abstracted from the new powders was much greater than that contained in their older rival; the rapidity of combustion was increased accordingly, and the violence of the explosion was developed to an alarming extent in some instances, especially where the Schultze powder had been very highly dried.

Other causes, however, had also been simultaneously at work, but these more especially affected the E.C. powder, which had not been very long before the public, and which had not then attained to the regularity of manufacture that has since been achieved. An early issue of E.C. was thought by some sportsmen to be rather too slow in its action, whereupon loaders of cartridges and manufacturers of caps set to work to remedy the defect. Some increased the charge, others introduced a priming of black powder, so as to quicken the action of the nitro-compound, and others made use of specially strong caps to effect the same purpose. Meanwhile, however, a new

sample of E.C. had been manufactured, which was probably as much too quick as the other had been too slow, and, the difference being unknown, it was loaded, in many cases, with the "aids to combustion" especially provided for its predecessor, whereupon results ensued that were decidedly unpleasant to the owners of the guns in which it was used.

Happily, however, the general state of affairs now is very different from what it was two years ago. The E.C. powder, as made at the company's new works, and under improved conditions of manufacture, has reached a very commendable degree of regularity. The cartridges with extra strong caps were soon withdrawn from sale, and other adventitious aids have been abandoned. Schultze, too, has been rendered much less sensitive to the effects of drying, and, instead of being more violent than E.C., as formerly was the case when the moisture was abstracted, it now appears to be the less affected of the two; while neither of them, as at present manufactured, gives any indication of being more dangerous in use than ordinary black powder.

As bearing on this subject, the following extract may be given from the Annual Report (for 1885) of Her Majesty's Inspectors of Explosives, under whose licence and supervision all gunpowder factories are carried on:

Among explosives for sporting purposes, Schultze gunpowder and E.C. powder continue to occupy prominent positions. A new factory near Dartford for the manufacture of E.C. powder on a considerable scale has been licensed and started during the year.

A foreign rival to these powders has appeared in the shape of Cooppal's powder, for the importation of which a licence has been granted to representatives of the Belgian manufacturers. The quantity of this powder which has been imported is not at present considerable, and it has yet to make for itself a trade.

We shall refer elsewhere to the useful experiments which have been instituted by the Editor of the *Field* with a view of illustrating the danger which in a greater or less degree generally attends the artificial drying of sporting powders of the nitro-compound class. [In a subsequent portion of the report lengthy particulars are quoted of the *Field* experiments, including many of the details which have already been given (pp. 17 to 22) and which therefore need not be reproduced here.] Attention to the points which these experiments are designed to emphasize will tend to procure greater freedom from the accidents which have from time to

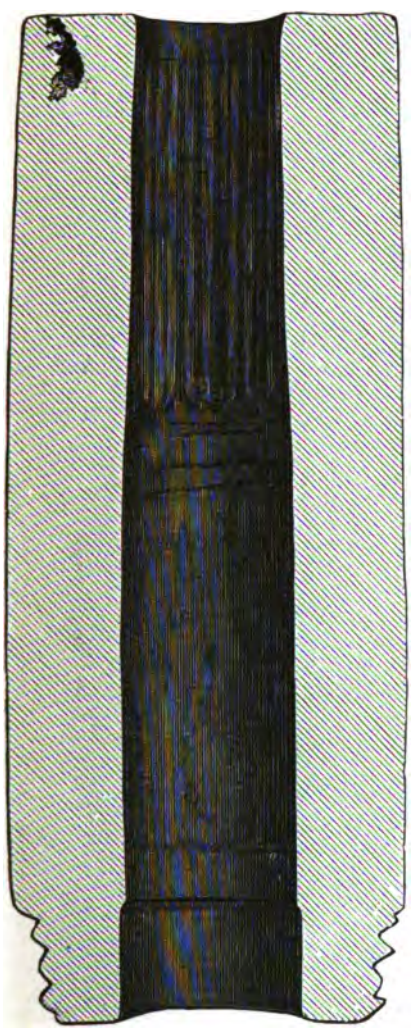


FIG. 1.—UNDRIED.

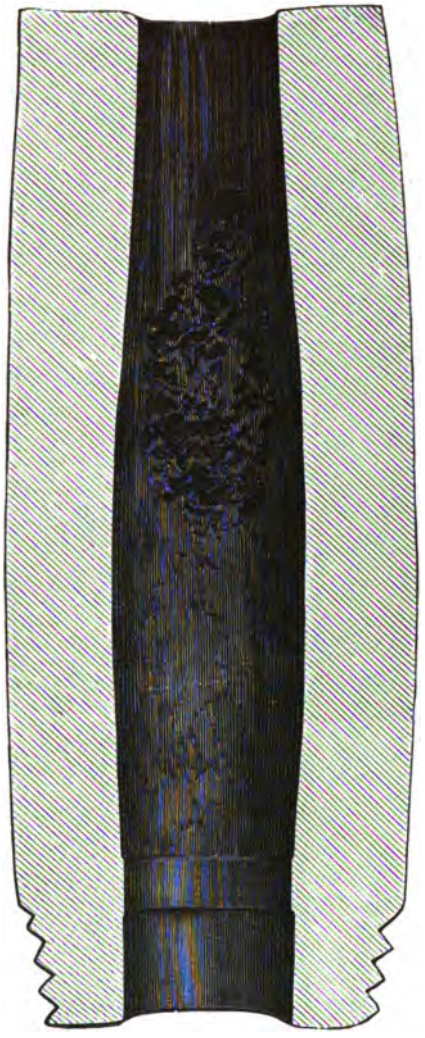


FIG. 2.—DRIED ONE HOUR AT 212°.

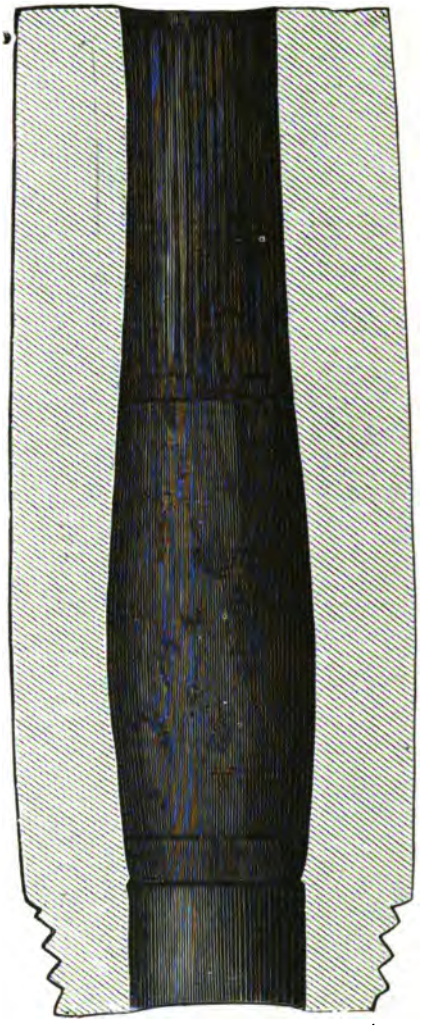


FIG. 3.—ABSOLUTELY DRY.

THE NEW SCHULTZE POWDER (1885).

time occurred with these powders, and which it cannot be doubted have powerfully hampered their progress in public favour.

The modification which has been effected in Schultze powder is designed to render this powder less sensitive to the action of moisture and of artificial heat, and therefore less liable to strain the gun when subjected to a drying process. [And in a footnote appended to the above remarks, the inspectors add: "It would appear from some experiments carried out since this report was written, and recorded in the *Field* of 14th and 28th February, 1885, that this result has been certainly largely achieved.]

In another portion of the report it is remarked that "more recently made batches of Schultze, of somewhat modified composition, exhibit paraffin, or, as it is often called, "paraffin wax." This answers a double purpose. In the first place, it acts as a kind of waterproofing coat to the grains of powder, thereby rendering them less liable to deterioration by absorbing extraneous moisture from the atmosphere in damp weather; and, secondly, it makes it more difficult to remove the normal amount of moisture introduced in the process of manufacture. Moreover, even if the normal moisture be extracted by persistent drying, the paraffin offers a kind of mechanical obstruction, and thus renders the process of combustion much less rapid than it otherwise would be. A somewhat similar effect is produced in the

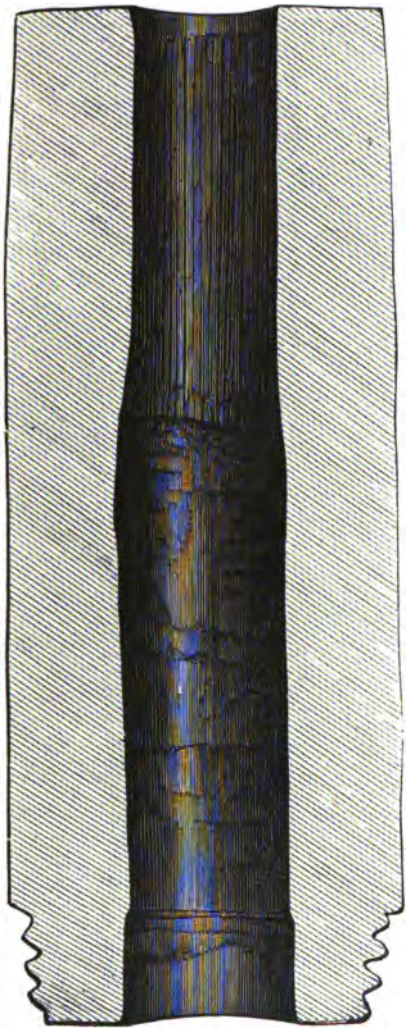


FIG. 4.—UNDRIED.

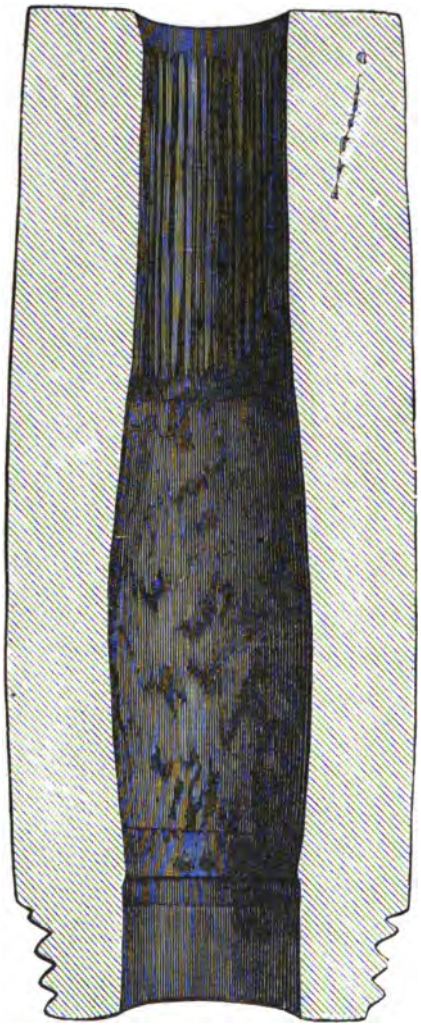


FIG. 5.—DRIED ONE HOUR AT 212°.

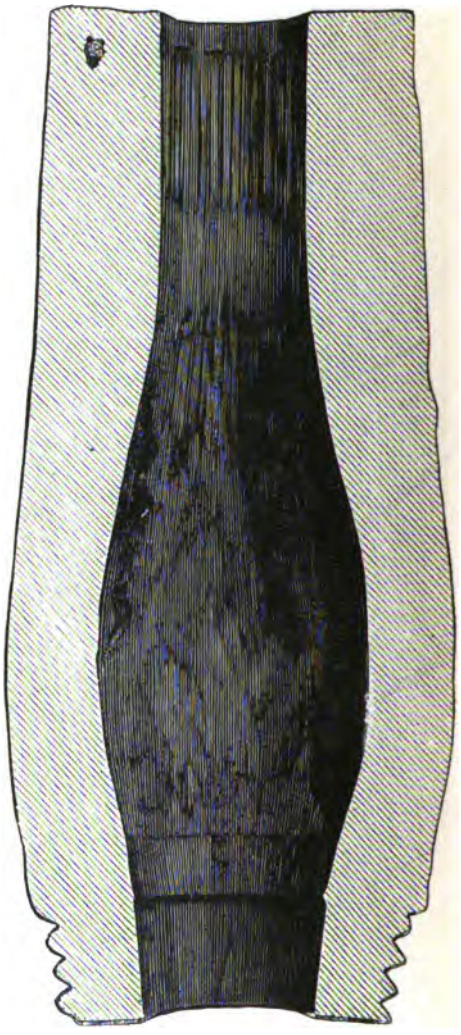


FIG. 6.—ABSOLUTELY DRY.

COOPPAL'S POWDER (1885).

this liability [to increase of force by drying] in a greatly diminished degree." Elsewhere it is stated that an alteration has been made in the "definition" according to which Schultze powder is manufactured, and that it is now defined as follows:

"*Schultze Gunpowder*, consisting of nitro-lignin carefully purified and mixed or impregnated with a nitrate or nitrates, other than nitrate of lead, and with or without starch or collodion (such collodion to consist of carefully purified nitro-lignin dissolved in commercially pure ether and alcohol) or pure solid paraffin, provided that such paraffin shall be free from mineral acid."

The main point of difference is in the introduction of the solid E.C. powder by other means; and a difference will be readily perceived, both in the new Schultze and the E.C., as compared with the old Schultze, by scattering a little of the powders on some water; for the old Schultze would soon sink, owing to the quick absorption of moisture, while the others will float upon the surface for a long time.

E.C. powders, and the guncottons from which they are made, are defined in the official report of 1882 in the following terms:

E.C. Sporting Powder, consisting of rifle guncotton, with the addition of colouring matter consisting of aurine (free from mineral acid) dissolved in a solvent composed of ether, alcohol, and benzoline.

Rifle Guncotton, consisting of guncotton or nitrated guncotton mixed with

any one or more of the following substances—viz., pure beeswax, paraffin, shellac, gums or resins dissolved in a solvent composed of ether, alcohol, and benzoline, provided that such substances shall be free from mineral acids.

Nitrated Guncotton, consisting of thoroughly purified guncotton, mixed or impregnated with a nitrate or nitrates other than nitrate of lead.

No alteration from this definition is made in the report of 1884, as there is no ostensible difference between the E.C of the present time and that made two years ago; but practically, as previously stated, there is greater uniformity in the strength of successive batches, owing to improved arrangements in the process of manufacture.

A third nitro-compound, recently introduced into this country, is Cooppal's powder, alluded to in a previous quotation from the Inspectors' Report. Dr. Dupré, the chemical adviser of the department, in reporting on the samples submitted to him for examination, speaks of this as "An explosive closely resembling an old-established explosive known as Schultze gunpowder; and as the sample passed through all the tests, the report was in favour its being licensed." A licence for its importation (it not being made in this country) was accordingly granted; and its "definition" is as follows:

Cooppal's Powder, consisting of nitro-lignin carefully purified, with or without admixture of a nitrate or nitrates (other than nitrate of lead) and starch.

All three of these powders have undergone experiments at the target in addition to those in lead cylinders, in order to test their relative shooting powers, when in their normal condition, as well as to ascertain the increase in explosive force produced by the drying of the powder.

The Editor of the *Field*, in reporting on his experiments with new powders issued at the beginning of 1885, gave the following details:

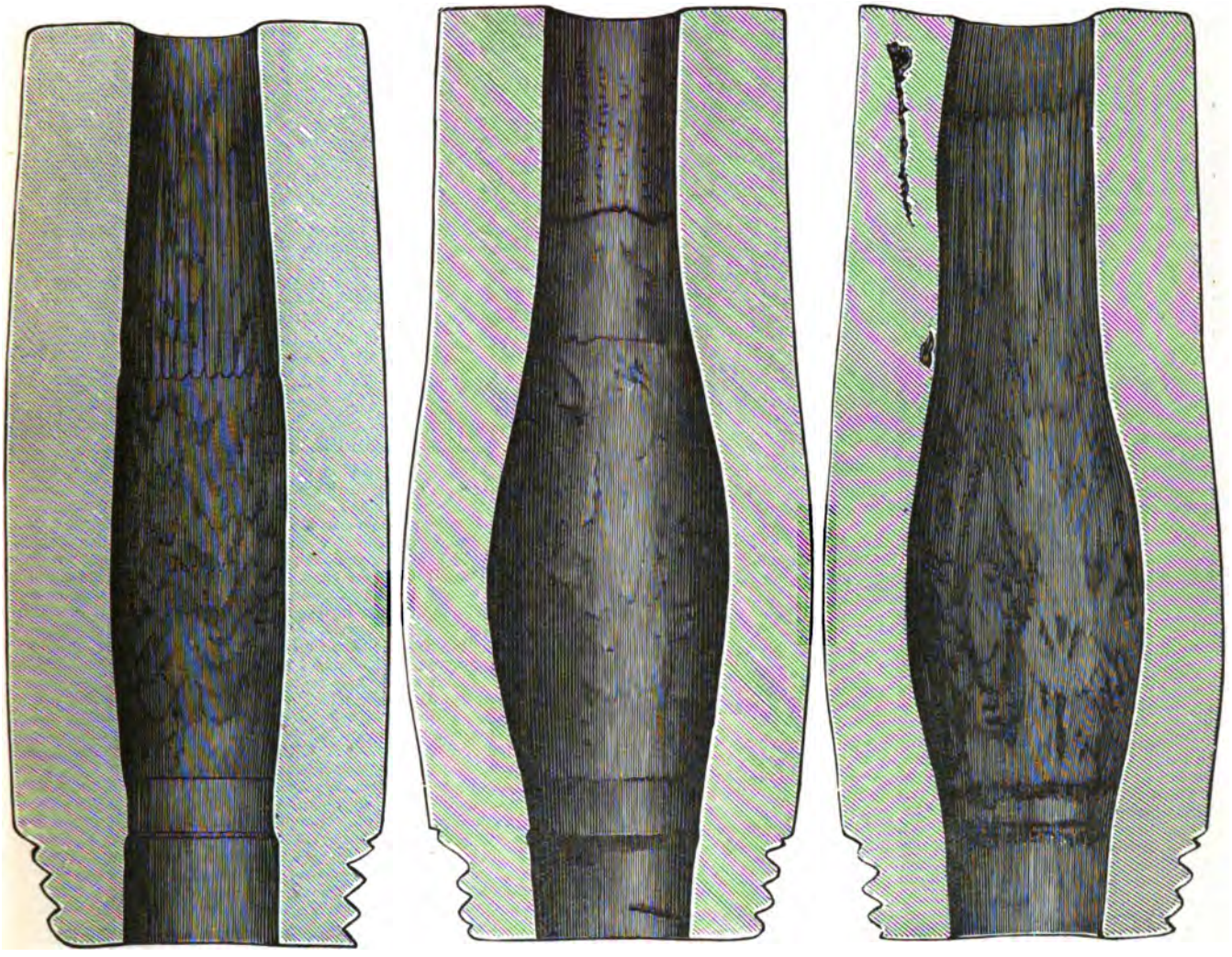


FIG. 7.—UNDRIED. FIG. 8.—ABSOLUTELY DRY. FIG. 9.—C. & H. No. 4 (3drs.)

E. C. POWDER (1885). BLACK POWDER.

THE NEW SCHULTZE POWDER.

"We have carefully tested the new Schultze powder, and find the statements of Mr. Griffith (the manager of the company's works) more than borne out by the results. It contains, as before, about 8 per

cent. of water capable of being driven off by heat; but it takes a much longer time to effect this operation (nearly four hours at 212° Fahr. being required to make it absolutely dry), and also re-absorbs the water much more slowly, requiring an exposure for six hours to an average atmosphere to take up 1 per cent. The specific gravity is about the same as before, so that the 3dr. black-powder measure contains 42grs. of Schultze; and there is no change in appearance, except that in the sample sent to us there is less dust than usual.

"From an examination of the leads, sections of which are engraved, it appears that in each case the dilation extends further up the chamber, as compared with the Schultze of the previous year—showing, apparently not only that a less initial force is exerted, but that the new powder does not burn so rapidly as the old. Hence we conclude theoretically that a slightly larger charge may be used with safety and efficiency—the former being apparent from the greatly diminished increase of force after absolute drying, but the proof of the latter must depend on the result of future trials. Taking 3drs. of C. & H. No. 4 as the standard, we find that the increased diameter from the black powder is ·49in. (see Fig. 9), the old Schultze powder of 1884 having given ·17. Testing for comparison the new Schultze powder of 1885, the dilatation is only ·09 (see Fig. 1, p. 23), but it is carried somewhat further into the barrel.

"Proceeding to test this powder after drying at 212° for one hour, we find, with a loss of 2 per cent. of water, the dilatation, instead of being ·95, as in the powder of 1884, is only ·20in. (see Fig. 2), but the dilatation extends further up the barrel as compared with the powder of 1884. On proceeding to test the absolutely dry powder—in which a loss of 3 per cent. had been effected by drying for nearly four hours at 212°—the dilatation was only ·31in. (see Fig. 3, p. 23), as against 1·09in. with the powder of 1884.

"The lead used this year is of the same quality as that employed last spring, so that the two series of experiments may fairly be compared together. We have also fired larger charges (54grs.) of the new powder, uncompressed and severely compressed, and the increased dilatation is so small as to show that larger charges may safely be used. We hope to give a full report of its action when tried at the target with the aid of our force-gauge; and should this new Schultze powder prove as useful in the field as the old issue, sportsmen may certainly congratulate themselves that a great improvement has been effected by the company making it."

[The trials at the target were carried out for the Editor by Mr. W. Jones, of Birmingham, the maker of the *Field* force-gauge, who also tried samples of Cooppal's powder and black powder, and details were given in the *Fields* of Feb. 21 and 28, 1885.

Cooppal's Powder.

"We have received from Mr Rigby, for trial, a sample of a new Belgian powder, which closely resembles the Schultze. It is known as 'Cooppal's Powder.' The specific gravity is slightly lower than that of E.C. and Schultze, so that, measure for measure, it weighs somewhat less.

"The best charge is said to be 48grs., with which we have therefore tested it. It contains about 2·5 per cent. of water, which it readily parts with and reabsorbs. The following is the result of our experiment with the lead cylinder: Using 48grs. of this powder, the dilatation of the lead (Fig. 4, p. 24) is ·12in., or slightly greater than that of the new Schultze. After one hour's drying at 200° Fahr. with a loss of 1½ per cent. water, the dilatation of Cooppal's (Fig. 5) was ·32 as against ·17 of the Schultze.

"After drying four hours, with a total loss of its water, the same powder produced the dilatation shown in Fig. 6—viz., ·58, as against ·81 with the new Schultze powder; but considerably less than the Schultze powder of last year."

E.C. Powder.

The Editor having been informed by the secretary of the E.C. Company that they had made no recent improvement in their powder beyond insuring perfect regularity, did not carry out any new experiments with this powder.

THE COMPARATIVE STRAIN ON SMALL-BORE GUNS.

During the shooting season of 1884-5, a large number of burst guns were brought under the notice of the Editor of the *Field*, and nearly the whole of them proved to be small-bores (which, from their lightness, have lately come very much into use), while the majority of them had been burst with nitro-compounds. With the view of ascertaining the difference in the amount of strain developed in 20-bores as compared with 12-bores, and likewise with black powder as compared with the nitro-compounds, the Editor had new apparatus made to fit the smaller-sized cartridges, and carried out an additional series of experiments. The following is the measurement of the dilatation in each experiment—the nitro-compound powder being partially dried in all instances:

No. 1. 12-BORE.

Powder.	Charge.	Dilatation.
C. & H. No. 4	3drs., 1oz. shot	·45in.
Schultze (1885), dried 2 hours	42grs., 1oz. shot	·19in.

No. 2. 20-BORE.

Powder.	Charge.	Dilatation.
C. & H. No. 4	2½drs., ⅞oz. shot	·36in.
,,	3drs., 1oz. shot	·52in.
Schultze (1885), dried 2 hours	35grs., ⅞oz. shot	·37in.
,, ,, ,,	35grs., 1oz. shot	·47in.
,, ,, ,,	42grs., 1oz. shot	·51in.
,, ,, ,,	50grs., 1oz. shot	·53in.

A sample of E.C. powder, obtained direct from the E.C. Company, gave results so closely resembling those of the new Schultze, that it was not thought necessary to print the figures; and the old sample of Schultze (1884) was not tested, because the investigations were intended to be of service for the future rather than of inquiry as to the past.

The following table will perhaps admit of more ready comparison, by placing the corresponding charges side by side:

Charges.	BLACK (C. & H. No. 4). Dilatation of 12-Bore.	BLACK (C. & H. No. 4). Dilatation of 20-Bore.	NEW SCHULTZE. Dilatation of 12-Bore.	NEW SCHULTZE. Dilatation of 20-Bore.
2½drs. or 35grs. and ⅞oz.	—	·36in.	—	·37in.
same with 1oz.	—	—	—	·47in.
3drs. or 42grs. and 1oz.	·45in.	·52in.	·19in.	·51in.
50grs. and 1oz.	—	—	—	·53in.

The 2½drs. charge, being seldom or never used in 12-bore guns, was not tried for comparison with the same charge in 20-bores. In the experiments with 3drs. of black and its equivalent 42grs. of Schultze, the two were very nearly equal in the 20-bore, although Schultze was considerably lower in the 12-bore. The additional strain in the nitro-compound, it will be observed, is not so much produced by adding to the powder as by adding to the shot—which necessarily increases the resistance, not only by the additional weight, but by the greater length of the mass of pellets compressed against the walls of the narrow barrel. When the charge of Schultze was raised from 42grs. to 50grs. the increase of dilatation was barely one-fourth of the increase that resulted from adding ⅛oz. to the shot used with 35grs. of Schultze. And it will be seen that, when the 20-bore charges were increased equally with black and Schultze (*i.e.*, from 2½drs. and ⅞oz. to 3drs. and 1oz.), the result was practically the same with both—the dilatation with black being raised from ·36in. to ·52in., and with Schultze from ·37in. to ·51in. With reference to insufficiency of strength in small-bore guns, the Editor remarked:

"It thus appears that the new powders—even when dried quite as much as is possible by the sportsman, and only containing about ½ per cent. of water—do not, in the 12-bore lead, exert so strong a pressure as a comparative charge of black powder. But in the 20-bore lead, while the pressure with the black powder is increased to some extent, the increase with the nitro-compound is in much greater proportion. Thus, in the 12-bore, the nitro-compound (using 42grs. and 1oz. shot) gave a dilatation of ·19in., but a similar charge in the 20-bore produced a dilatation of ·51in.; yet, even then, it did not exceed that of the black powder. This shows that, instead of reducing the strength of 20-bore barrels as compared with 12-bores (which is the ordinary practice), they ought, on the contrary, to be increased in substance. We may remark that the largest charge here used (50grs. and 1oz. shot) just fills the 3in. cases now frequently employed with the 20-bore, and that charges quite as large as this have been used in cartridges by which guns have been burst.

From what we now know, we can strongly caution our readers against trusting 20-bore guns, and more especially 28-bores, if sold by unreliable gunmakers, and especially if the barrels are light. The difference in the area of the metal composing the 12 and 20-bore barrel is as about 100 to 85; so that, even supposing the strain on each to be the same, the reduction in weight ought to be in somewhat similar proportion. Now, the 12-bore double barrels should not weigh less than 3lb. 2oz., and at the above rate the 20-bores should weigh 2lb. 12oz., whereas they are frequently made as light as 2lb. 7oz., or even less. This may be readily proved when we know that the stocks, locks, and fore-ends of the two guns are nearly of the same weight,

7oz. or 8oz. being the utmost that can be got off the small bore. Now, many of these guns are made of 5lb. weight, and, deducting 3lb. or a trifle less for the stocks, &c., this leaves only 2lb. for the barrel, or at most 2lb. 4oz., instead of 2lb. 12oz., which they ought to be; or a reduction of 30 per cent. instead of about 15.

Remarks on the Difference of Pressure by Black Powder and Nitro-Compounds.

Some surprise has been expressed at the results of the experiments above described, inasmuch as they show that the nitro-compounds, under their normal conditions of use by sportsmen, indicate, by their effect upon the lead cylinders, a lower explosive force, or strain upon the barrel, than that exhibited by black gunpowder. And, seeing that the former have fully as great propulsive power as the latter—or, in other words, "shoot quite as hard"—many persons imagine that quite as high a degree of pressure must necessarily be exerted in the gun. This, however, is a fallacy. Numerous artillery experiments, carried out on behalf of the Government, have demonstrated beyond question that the strain or rending force exerted in the barrel has no corresponding relation with the velocity imparted to the shot. The rending force of an explosive substance varies with its velocity of combustion; and one charge of powder which produces an enormous strain in the chamber of a gun may actually impart less speed to the projectile than a charge of a slower-burning powder that does not strain the barrel half as much. The impetus given to the shot depends, not on the extreme force developed in the powder chamber, or at any particular point in the barrel, but upon the most effective combination of the varying degrees of pressure which occur between breech and muzzle—in other words, on the best average.

Such were the results of experiments carried out solely with black cannon powders, of virtually the same chemical composition—the differences in effect being produced by variations of detail in manufacture, which modified the rate of combustion. But our sporting powders are divided by a much broader line, as the nitro-compounds are distinguished from the black powders by chemical differences, which accentuate in a marked degree the effects producible by mechanical changes in the manufacturing process. Guncotton—the prototype of these nitro-compounds—may be one of the most violent of explosives, owing to its extreme rapidity of combustion under certain circumstances; yet, by a change of mechanical condition, it may be so altered as to burn gradually away without explosion, and be held in the fingers while it is slowly consumed. Whether the guncotton burns quickly or slowly, the quantity of gas it gives off is much greater than that evolved by black powder, although not so obvious to the sight; and it is this superiority of gas production that enables the nitro-compounds, with equal rate of combustion, to perform as much work as black powder with less strain on the gun.

The force exerted by an explosive substance is dependent partly upon the quantity of gases liberated, partly on the rapidity with which they are evolved, partly on the resistance they meet with, and partly on the extent to which they are heated. These apply both to the nitro-compounds and the black powders; but there is another matter which may be said to exclusively affect the black powder, and that is the influence of the solid products of combustion in enhancing the pressure of the gases.

The black sporting powders of our best English makers, although varying in grain, density, and other details, all give off practically the same volume of gases for an equal weight of powder. With the nitro-compounds, however, the volume of gases evolved would be three or four times as great as from an equal weight of black powder. (For the sake of simplification let us say four times, although it may not actually be quite as much.) We must not forget, however, that black powder is about twice as heavy as the nitro-compounds, while the charges used (by measure) are equal; so that the volume of gases from a charge of Schultze or E.C. would be, not four times, but about twice as great as that from an equivalent black charge.

Hence, if nothing more than mere quantities of gases were concerned, the black powder would have but half the strength of the nitro-compounds. But heat has also to be taken into consideration, and that which is wanting in volume of gases is made up to black in the way of temperature. Every sportsman knows that gunbarrels are much less heated by Schultze and E.C. than they are by black powder, but all may not be equally well acquainted with the fact that the expansive force of gases increases with the heat to which they are subjected, and that the wide difference in the temperature of barrels, after rapid firing with these two classes of powder, is an indication of the difference of means whereby they effect the work which they carry on inside the gun.

Between black powder and the nitro-compounds, moreover, a marked difference is shown in the quantity of solid residue resulting from combustion. It has been ascertained by Sir F. Abel that the solid residue from black powder amounts to more than one half (or nearly 60 per cent.) of the original weight of the charge. On the gun being fired, some of this dirty black refuse adheres to the barrel, but the great bulk is blown out in the dense smoke so characteristic of black powder. Solid particles necessarily occupy space, and, by so doing, they must, when in the chamber of the gun, have an influence upon the pressure of the gases with which they are confined. Let us suppose, by way of illustration, that the powder-charge in a gun occupies one cubic inch of space (of course it would be less in a 12-bore), and that the solid particles of refuse are equal in bulk to one half the original charge. If, upon firing the cartridge, all the powder were burnt before the shot made any appreciable movement, one half of the cubic inch would be occupied by solid particles, by which the space for gases would consequently be limited to the remaining half, and, being thus compressed within half the cubic inch, the gases would exert double the force they would have done if the solid residue had been absent, and they had had the entire inch to themselves.

The nitro-compounds, on the other hand, have so little solid residue that, for the purpose of this argument, it may be disregarded. And, taking into consideration the circumstance that a nitro-compound charge evolves twice as much gas as its equivalent of black powder, we may arrive at the conclusion that, supposing the speed of combustion to be equal in the two powders, the double quantity of gas with no solid residue would give, within the cubic inch of space, the same degree of pressure as would be exerted by the single quantity of gas intermingled with half a cubic inch of solid particles.

Such a condition of things, however, would last only so long as the gases are confined within the powder-chamber. As the shot moves up the barrel, the gases would expand, but the solid particles would not. Consequently, if we suppose the total capacity of the barrel to be 30 cubic inches, there would, in the case of the black powder, be still half a cubic inch of space occupied by the solid particles, but the gases that had been confined to the other half inch would be expanded into 29½ cubic inches, or 59 times the former space, and be attenuated accordingly. In the case of the nitro-compound, however, with double the volume of gas and no solid residue, the expansion would be from one cubic inch to 30 cubic inches, and it would suffer to only about half the extent of the black powder by attenuation of gases. Accordingly, in the course of their expansion throughout the barrel, the one lot of gases would be capable of doing nearly twice as much work as the other, although the highest pressure of both would be equal.

No allowance, however, has yet been made for difference in temperature; and, as already intimated, the heat developed by the black powder is much higher than that from the nitro-compounds. Gases double their bulk, or expansive force, when raised from a cold state to a temperature of about 500° F., and go on increasing at about the same rate to much higher temperatures; and, as the heat produced by black powder has been found to rise as high as 4000° F., there is ample margin for a very wide range of difference in temperature between the gases of the two powders, although we may not know the exact extent. Whatever it may be, however, it would be in favour of the black powder, as producing a considerable accession of strength. It must not be forgotten, though, that this accession of strength lasts only so long as the temperature endures, and that, directly the gases are able to expand, by the movement of the shot up the barrel, they begin to lose heat; so that they are not only attenuated by the occupation of increased space, but they are further diminished in force by the cooling they undergo. A very good illustration of the effect of expansion in reducing temperature is to be seen in the method adopted in the refrigerating chambers of some of the vessels which bring so many carcases of dead meat from the Antipodes. Air is compressed by the ship's engines, and becomes heated by the compression, whereupon it is passed through pipes laid in water, and the heated air is thus lowered to the temperature of the sea; in the refrigerating chamber, the compressed air is allowed to escape, when it naturally expands, and, in so doing, falls so much in temperature that the atmosphere of the chamber is brought down below freezing point. A somewhat similar process is gone through in the gunbarrel. The gases evolved by the combustion of the powder undergo a great deal of compression in the chamber; and the more rapidly the combustion takes place, and the greater the amount of resistance, the more the gases become heated. A small amount of heat is carried off by the conduction of the metal, but the time is too short for this to have much effect, as, immediately the shot moves and allows additional space to the gases, they begin at once to expand, and lose heat rapidly till they pass out at the muzzle.

The nitro-compounds ignite at a much lower temperature than the black powders, and the gases being about double in quantity, they need only expand half as much in order to fill the barrel. Moreover,

from their chemical composition, the nitro-compounds form a good deal of water in the process of combustion; and, inasmuch as a large amount of heat is rendered latent in the conversion of water into vapour, the temperature does not rise to the extent it would do if true gases alone were formed. Thus, several agencies are at work that tend to moderate the temperature in the nitro-compounds; their gases accordingly lose much less by expansion, and therefore retain to the last a greater proportion of their original force.

The extent to which the gases of black powder diminish in power during the passage from the chamber to the muzzle of an ordinary sporting gun has never been ascertained,* but some idea may be formed upon the subject from what has been learned by artillery experiments. The powder-chamber of a cannon which was experimented with occupied about one-sixth of the entire length of the barrel. Consequently, if this chamber were filled solely by gases, the pressure, on their expanding to the muzzle, would (if no loss of heat were sustained) be one-sixth of what it had been at the breech. But, instead of one-sixth, the pressure only amounted to one thirtieth of what it had been in the chamber. As, however, it was black powder, we may assume that half the space in the chamber was occupied by solid residue; in which case the gases, when the shot reached the muzzle, would occupy eleven-twelfths of the space, and the pressure should be one-eleventh of what it had been in the chamber, were there no loss of temperature. However, as before stated, the pressure was only one-thirtieth of what it had been—thus showing that, in the course of ten expansions, so much heat had been lost as to reduce the power of the gas by about two-thirds. And, if such be the case where there are only ten expansions, what reduction of force must there be where, as with sporting guns using black powder, the number of expansions would be about sixty instead of ten, and the gas be thus cooled as well as attenuated! With nitro-compounds the expansions would only be about half as numerous, and there would consequently be less loss of force.

Much more might be said with respect to certain branches of this rather complex subject, but, a great deal of space having already been occupied, it may suffice to summarise the matter thus: When the two kinds of powder perform equal work, the black does so by great heat and a large exertion of force at the commencement, whereby it makes up for the rapid loss of power which attends its expansion in the barrel. The nitro-compounds, owing to their greater abundance of gas and lower temperature, do not lose power to the same extent, and, by retaining a more equable pressure up to the muzzle, do not require so high an initial pressure to accomplish the work that has to be done. The effect is made obvious to the eye when one looks at the different degrees of dilation shown in the lead cylinders represented in Figs. 1, 4, and 7, as compared with Fig. 9 (*see* pp. 23, 24, and 25).

These remarks have reference, of course, to the nitro-compounds used under ordinary conditions of loading in sporting shot guns, and in the state in which they are issued by the makers. If, by putting black powder in with the nitro-compounds, an excessive amount of heat is created, or if by other means the powders are made to liberate their gases more quickly than they are intended to do, the very abundance of these gases, which enables them to work at a low maximum pressure under normal conditions, may possibly be turned into a source of danger. The manufacturers of these powders have taken great pains to render them less sensitive to drying than they were a year or two ago; but, whether they have entirely succeeded in rendering them equally as capable as black powder of withstanding outward interference, is a question which only time can determine.

W.—T.

* Since this article was published, many experiments have been carried out. *See* the curves of pressure given subsequently (pages 34 and 35).

LEADEN CYLINDERS FOR TESTING GUNPOWDER.

(*Field*, Sept. 5, 1885; Vol. 66, p. 355.)

SIR,—I unfortunately have not had the opportunity until this week of seeing the report of the late trial "The Guardians of the Birmingham Proof House *v. The Field*" [published in *The Field* of Aug. 15, 1885].

I am sure the evidence given must have been of great interest to many of your readers, as it threw a strong light upon the method adopted by the Guardians in ascertaining that the powder used in testing was of the regulation strength.

I observe that in your evidence you refer to your visit to the Stowmarket Gun Cotton Works in 1883. I had then the pleasure of bringing before your notice a method I had invented of testing by means of lead cylinders the comparative strains exerted by different powders on the breech of a gun, and was very much pleased to hear you express your approval of my method; and as you have since used this method in carrying out various and important experiments, I have no doubt you considered it the most reliable and practical test that had yet been introduced.

I notice that attempts were made during the cross-examination to discredit the reliability and uniformity of this method of testing, and various insinuations were made with regard to the difference in the test that might be caused by a variation of density resulting from the temperature of the lead at the time of casting the cylinders.

As the inventor of this system, and one who has worked at it most extensively, I have found that, with ordinary care in casting the cylinders, the difference in density is not of any importance; and that in several experiments with ordinary castings from lead at the highest and lowest possible temperatures, the difference in densities was only found to be 1·4 per cent.; and between castings from lead at the highest possible heat, and from lead at the temperature at which it is usually cast, the difference was practically *nil*—thus showing that, within certain limits, it really makes no difference whether the lead cools down from a high temperature in the pot or in the mould.

I may state that I for some time passed the cylinders I used through a steel die, by hydraulic pressure; this gave an increased finish, but as I found no advantage on the score of uniformity, whereas the cost and trouble were considerably increased, I discontinued this operation.

In reference to the uniformity of commercial lead, in numerous experiments I invariably found the Newcastle "pig" very uniform indeed; but I cannot say the same of London brands.

I should therefore say, seeing that commercial lead can be obtained practically uniform, there should be no difficulty in establishing a universal cylinder test, by which gunmakers and sportsmen could by a quick and simple method ascertain if their latest batch of powder or cartridges exerted a greater or less strain than former batches.

Of course, for this purpose, a definite form of cylinder would require to be decided upon and adhered to, so as to get comparable results.

I do not quite agree with you that the six-inch cylinder used by you is better for all purposes than the one used here during your visit. The six-inch has doubtless some advantages, especially in testing such large charges as you have been doing in your late experiments; but for factory work and ordinary purposes, the six-inch cylinder is much too large, the smaller cylinder being much more within the limit of manufacture, and easier manipulated. The cartridge also occupies exactly the same position in relation to the barrel that it does in an ordinary gun, and, upon being discharged, the turn-down laps over the joint between the cylinder and the gun barrel, the shot therefore passes into the barrel without at all coming into contact with the lead, as it does in the six-inch cylinder; the above arrangement also, to a great extent, prevents the escape of gas—which I found, before I adopted the screw, to be considerable.

I was amused at a suggestion made in the cross-examination, that the fixing of the lead cylinder at both ends converted the sides into what was termed a kind of "lever." This certainly is a very extraordinary expression, and could only have been made use of by some one who had more knowledge of the mechanical term than of the meaning of the words he was using.

I am very glad to see that you have in such a short time been successful in awakening the proof authorities to a sense of their duties—a task which gunmakers apparently failed to accomplish after many years of agitation.

J. M. T. ANDERSON.

Stowmarket, Sept. 2, 1885.

[We are much pleased at receiving the above letter, and quite agree with Mr. Anderson that the short leaden cylinder is better suited to small charges than the longer one. But for large charges we much prefer the latter, because there is no escape of gas either at the breech or the junction with the barrel, and moreover, from the increased length, the extent of the strain down the barrel is clearly indicated as almost ceasing within the cylinder. For ordinary purposes, a 6in. lead, with a lock for exploding the cap, is quite sufficient without a barrel. We understood when at Stowmarket that Mr. Reid was the inventor and Mr. Anderson the maker of the machine we saw there. —ED].

(*Field*, Sept. 12, 1885; Vol. 66, p. 391.)

SIR,—With reference to the letter on lead cylinders which appeared in your last issue, will you allow me to state that the testing gun which I had the pleasure of showing you at Stowmarket in 1883 was made there under my direction, with the aid of my assistants, Messrs. Anderson and Borland. I had long previously used lead cylinders in the investigations which led to the invention of the E. C. powder, and for comparing the strains produced by different explosives. The invention of these cylinders for testing purposes is, I believe, due to

Trauzl; but this form has long since been abandoned in Germany, where they were first used. Their chief defect is that, to obtain accurate results which can be fairly compared with each other, a different thickness of lead must be used for each kind of explosive, or for different charges. Where a heavy charge or a powerful explosive is used in a cylinder of the same dimensions as for a light charge or a weaker explosive, the initial development of gas dilates the lead to such an extent that the sides of the cylinder may be unable to resist a comparatively moderate final pressure. A lead cylinder, the outer sides of which have been perceptibly bulged, must be considered as an exaggerated or magnified illustration of the action which has taken place inside it, and is not a direct measure of such action. It may be regarded as an indication that the pressure in one case is greater than in another, but it does not show how much greater the pressure is.

The materials of which guns are constructed do not yield in this manner; so long as the metal remains intact, the resistance to the outward pressure is practically the same at the beginning and during the progress of the explosion.

The present practice in Germany, when lead is employed for testing explosives, is to use a block of very large dimensions with a small borehole. The explosion produces no deformation of the external surface of the block, and the cavity is produced by the compression of the lead alone. I have made numerous experiments by both the old and new methods, and find the latter fairly accurate.

There is no difficulty in obtaining lead of uniform hardness, provided the temperature of casting be the same in each case. For small cylinders Gen. Rodman's process of hydraulic compression is advantageous, but it increases the hardness of the lead as compared with the uncompressed metal.

In comparison with the copper of crusher gauges, lead is, I think, much more uniform. Gen. H. L. Abbot, in his interesting researches on high explosives for the American torpedo service, abandoned the use of copper, and adopted lead, which gave very satisfactory and uniform results.

I think lead cylinders are very useful as an indication of increased strain; but they do not afford the means of measuring the increase with sufficient accuracy. They are, however, in my opinion, preferable to crusher gauges, the defects of which are well-known.

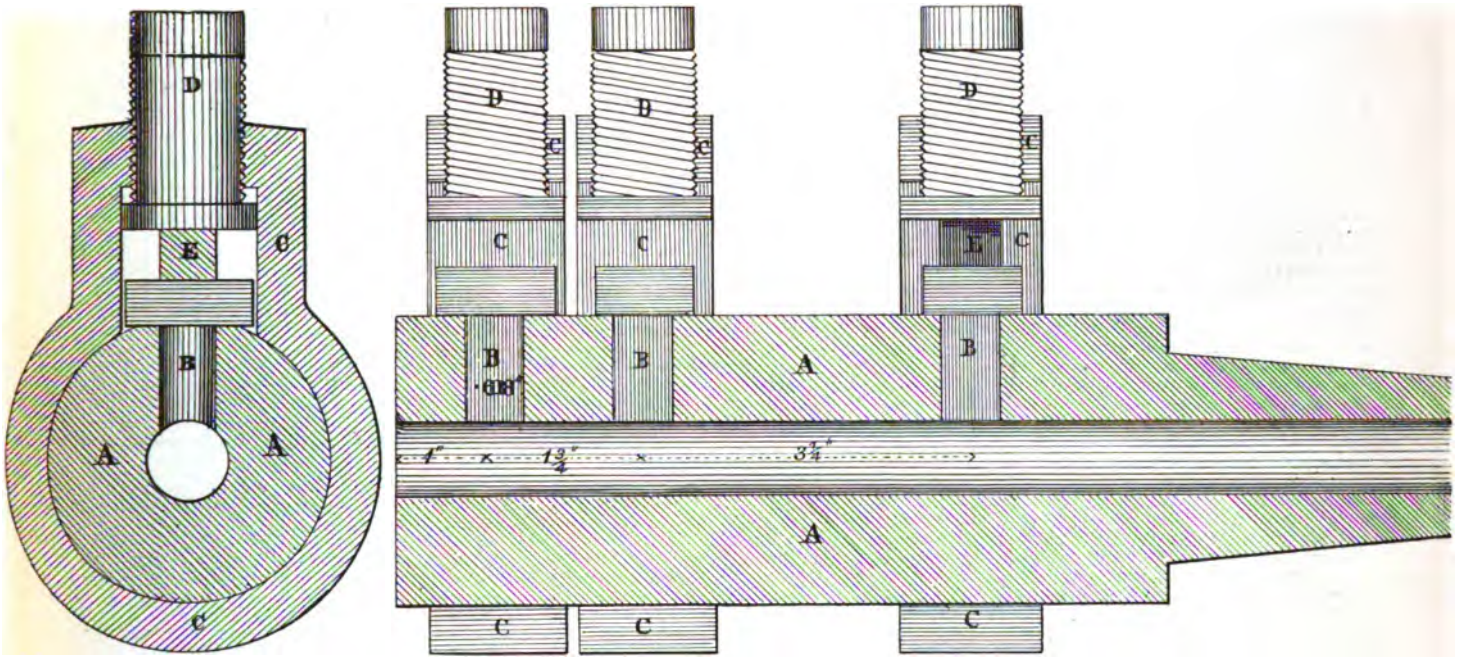
I am glad to see that your efforts to reform the proof of guns are meeting with success, and trust the matter will not be allowed to drop until a method of testing is adopted which will command the confidence of the public and of the gunmakers.

Pembrey, S. Wales, Sept. 9, 1885. WALTER F. REID.

CRUSHER-GAUGE EXPERIMENTS ON THE BURSTING FORCE OF GUNPOWDER.

(*Field*, Nov. 20, 1886; Vol. 68, p. 733, 771, 833, 836, 838.)

WE have long contended that the powder ordinarily employed for proof purposes has much less strain, or bursting force, than a sporting powder such as No. 4 T.S., which is the grain mostly used for shot guns by those who still adhere to the black explosive. We have carried out experiments which, in the opinion of others as well as ourselves, have fully proved our contention; but the Birmingham Proof-House authorities, in the course of the action which they brought against us last year [1885], declined to accept our conclusions, and endeavoured to confute them by bringing forward certain results obtained by other methods—which methods we believed to be wholly unreliable. We are therefore glad that an opportunity has occurred of making public the results of a new series of experiments, carried out not only by a person independent of both sides, but by one who has had great experience in matters of this kind, having conducted more systematic investigations with respect to the force of the various kinds of sporting powders, the velocities of the different sizes of shot, and the effects arising from alterations



in the charges of shot guns, than anyone whom we are acquainted with.

The gentleman referred to is Mr. R. W. S. Griffith, whose mechanical as well as chemical knowledge, and special opportunities as manager of the works of the Schultze Gunpowder Company, have given him advantages in experimental research of this kind, such as very few persons can possess. But, before entering into an explanation of these experiments, we may recapitulate a few facts with respect to the general question at issue, which has often been touched upon in our pages in consequence of the safety of sporting guns being a matter that closely concerns the life and limbs of so many among our readers.

It probably will be remembered by those who followed the particulars we published last year relative to the legal trial, that we contended that experiments made to ascertain the explosive force of gunpowders by means of a single crusher-gauge (as relied on in evidence produced on behalf of the Proof-House Board) could not be trustworthy, because a crusher-gauge placed at one fixed point could not possibly indicate the relative amount of force exerted by the different samples of powder at other parts of the gun. Accordingly, as we contended, the experiment described in evidence could not meet the requirements of the case at issue; and it differed in a most

essential respect from the Government ordnance experiments upon which that trial of proof-powder for small arms was supposed to have been based. In the Government tests a large number of crusher-gauges had been employed, and these were distributed throughout the whole length of the bore, the chamber included; whereas in the proof-powder test adduced there was one crusher-gauge placed more than an inch in front of the chamber, and none whatever within it.

When commenting in the *Field* of Aug. 15, 1885, upon the case that had just been tried, we alluded to the above-mentioned Government experiments, which had shown that the greatest strain from the quick-burning powder occurred in the chamber itself; whereas the slower-burning powders all gave their highest pressure after the shot had moved some distance—that distance varying with the rate of combustion of the powder. Such facts as these could never have been ascertained by means of a single crusher-gauge, wherever it were placed, and we accordingly remarked:

However accurate this test may be when carried out in its entirety, it must be obvious, on very superficial observation, that the conditions are entirely changed when, instead of a succession of crusher-gauges at different points of the bore, there is but one crusher in the whole length of the barrel. A single crusher-gauge does not give any information as to the greatest strain of the powder, as it affords no comparison of the intensity at different points; consequently it can give no information respecting the relative bursting force of different powders, seeing that, even though its record be perfectly correct with respect to one sample of powder, it would not show the greatest strain of another sample of powder which had either a quicker or a slower rate of combustion.

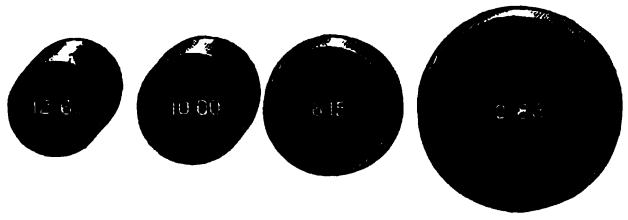
Illustrations copied from the lead cylinders used in our own experiments showed, too, not only that the point of greatest strain varies with different powders, but that it changes with an alteration of condition in the very same sample; for, the more rapid the combustion of the powder—whether it results from difference of grain or a reduction in the amount of moisture—the more intense is the strain, and the nearer to the breech it is produced.

The accuracy of our contention is now fully supported by experiments which have for many months past been independently carried on by Mr Griffith, who has worked them out with great skill and patience, by means of a three-crusher instrument, similar in principle to that used in the Government experiments with cannon, but adapted to the testing of charges used in sporting guns of 12-bore and 20-bore, and made according to a design of his own, of which we give an illustration (on page 29). The 12-bore and 20-bore apparatus are just alike, except as regards the difference in calibre.

It will be seen that two sections of the apparatus are represented (an end view and a side view), given at half scale, the calibre being 12-bore, the steel (AA) rather over an inch in thickness at the breech end, and the length of the portion depicted being nearly a foot; the rest of the barrel is omitted from the woodcut, out of consideration for space. The metal of the upper side of the barrel is perforated so as to admit three steel plugs or pistons (BBB), ·618 inch in diameter, or ·3 sq.in. sectional area, and of the length requisite to fill the perforation in the barrel. On the plug is placed a leaden cylinder or disc (E) to be crushed by the force exerted by the powder gases. This leaden cylinder is only about half the diameter of the cavity in which it is placed, and therefore has plenty of room for lateral expansion when it is compressed in length. The first plug is placed an inch from the breech; the second is 1⅝in. in advance of the first, and consequently clear of the ordinary 2½in. cartridge case; while the third plug is 3½in. further forward, and therefore 6in. from the breech. Three collars (CCC) fit round the barrel, over the plugs and discs; and the screw-adjustors (DDD) are screwed down so as to hold the two steel plugs firmly where no lead disc is inserted, or, where there is one, to prevent the lead rising when the plug is driven upwards by the pressure of the gas.

The crushers are carefully made of pure lead, squeezed into a steel mould under heavy pressure, so as to ensure equal density, then cut exactly to the same length (12·60 millimetres, or half an inch), and weighed, those being rejected which vary more than half a grain from the regulation weight. The extent to which these leads are shortened by pressure has been ascertained by a long series of experiments with dead weights, the measurements being made by a micrometer to the hundredth part of a millimetre, or about the 2500th part of an inch. The measurements are made after the disc has been allowed to cool, as, if made immediately, when heated by the compression, the dimensions then taken are not to be relied on.

The accompanying drawings represent several of the leads, "life size," the one marked 12·60 not having been compressed, but the others are reduced to the thicknesses marked thereon, and expanded laterally in accordance with the extent of the compression. That which is marked 10·00 is from the third plug, when 42grs. of Schultze and 1oz. were fired in the 12-bore; that marked 6·15 is the second plug with the same charge; and that marked 2·88 shows the compression with 3½ drs. of No. 4 and 1oz. shot at the first plug in the 20-bore.



The following table shows the actual measurements of the leads used by Mr. Griffith in a series of experiments which he carried out with No. 4 black and Schultze powder.

COMPRESSION OF THE LEAD DISCS BY THE EXPLOSIVE FORCE OF THE POWDER.

The original length of each lead was 12·60 mm., or half an inch. After firing the charge, the thickness of the discs at the respective plugs was as follows:

Bore and Charge.	Black Powder.			Schultze.		
	1st plug.	2nd plug.	3rd plug.	1st plug.	2nd plug.	3rd plug.
12 Bore.	mm.	mm.	mm.	mm.	mm.	mm.
2½drs. and 1oz.	7·08	8·00	10·88	9·70	10·20	11·15
,, ,, 1⅛oz.	6·60	7·20	10·61	8·75	8·20	10·65
3drs. ,, 1oz.	6·16	6·50	10·16	6·58	6·57	10·20
,, ,, 1⅛oz.	5·76	6·48	10·12	6·30	6·15	10·00
3½drs. ,, 1⅛oz.	4·66	5·42	9·55	5·98	5·20	9·17
,, ,, 1¼oz.	4·24	4·92	9·14	5·15	4·83	8·99
4drs. ,, 1¼oz.	3·58	4·12	8·67	4·30	4·20	8·50
20 Bore.						
2drs. and ⅞oz.	5·92	7·28	10·90	9·15	8·65	11·20
,, ,, 1oz.	5·48	6·85	10·50	8·16	7·80	10·81
2½drs. ,, ⅞oz.	5·01	6·50	10·35	7·50	7·15	10·25
,, ,, 1oz.	4·60	5·88	9·93	6·54	6·19	10·12
3drs. ,, ⅞oz.	3·80	4·80	9·45	5·65	5·40	9·50
,, ,, 1oz.	3·42	4·28	9·30	5·58	4·98	9·15
3½drs. ,, 1oz.	2·88	3·71	8·88	4·80	4·41	8·64

The Black powder used throughout was C. & H. No. 4 T.S.; and the shot was No. 6 chilled.

These measurements, when translated into pounds per square inch, give the following records of pressure, with the respective charges stated:

AMOUNT OF PRESSURE (IN POUNDS PER SQUARE INCH) AT THE RESPECTIVE PLUGS.

Bore and Charge.	Black Powder.			Schultze.		
	1st plug.	2nd plug.	3rd plug.	1st plug.	2nd plug.	3rd plug.
12 Bore.	lb.	lb.	lb.	lb.	lb.	lb.
2½drs. and 1oz.	1640	1448	916	1124	1030	858
,, ,, 1⅛oz.	1760	1616	964	1304	1409	958
3drs. ,, 1oz.	1910	1780	1040	1768	1770	1030
,, ,, 1⅛oz.	2090	1796	1046	1850	1910	1067
3½drs. ,, 1⅛oz.	2800	2280	1160	1962	2414	1222
,, ,, 1¼oz.	3110	2621	1238	2444	2684	1257
4drs. ,, 1¼oz.	3770	3210	1321	3063	3120	1352
20 Bore.						
2drs. and ⅞oz.	2001	1600	912	1227	1323	850
,, ,, 1oz.	2240	1767	980	1418	1498	928
2½drs. ,, ⅞oz.	2542	1790	1006	1550	1627	1022
,, ,, 1oz.	2825	2015	1060	1772	1890	1046
3drs. ,, ⅞oz.	3520	2676	1171	2140	2290	1162
,, ,, 1oz.	4050	3083	1200	2182	2560	1226
3½drs. ,, 1oz.	5200	3620	1279	2676	2960	1322

[It has been found, as the result of subsequent experiments, that although the pressures here stated may be relatively proportionate to the amount of stress given by the respective powders and charges, the actual pressures are higher, as the dead-weight pressures, on which the scale was originally framed, were allowed to remain on too

long. A new scale has since been prepared, a copy of which is printed at page 37.]

The pressure at the first plug, it should be stated, is taken with the cartridge case complete, and, as the force of the gas drives up the steel plug, the paper of the case is more or less punched out. The force taken to effect this necessarily reduces the record made by the first crusher-gauge, and Mr. Griffith informed us that when the paper is cut before firing the cartridge, so as to let the gas act directly on the plug, the record is raised from 50lb. to 100lb. The cartridge case, however, practically forms a part of the gun, and accordingly lessens the strain upon the barrel when in ordinary use in a somewhat similar way. In the following remarks on the variation of pressure at the successive plugs, the percentages are calculated on the amount of force actually recorded, no allowance being made for the fact that the paper case was in operation at the first plug but not at the second and third.

With black powder (C. & H. No. 4—the kind always referred to here when no other grain is stated), the greatest pressure was recorded by crusher No. 1, situated an inch from the breech, and consequently just about the end of the powder with 3dr. charges in a 12-bore; but, whether the charges were above or below the average, and whether in the 12-bore or the 20-bore, the highest record with black invariably was made by the first crusher. On the other hand, with Schultze powder, the highest strain, in every instance but one, was marked by crusher No. 2—the exception being with the smallest charge of the 12-bore series. This second crusher is placed 2¾in. from the breech, and therefore just beyond the extremity of the chamber with the ordinary cartridge case; so that its position is nearly the same as that of the single crusher which was used in the experiments relied upon by the Birmingham Proof-House Guardians. Now, if that crusher alone were used in testing the relative strengths of Schultze and C. & H. No. 4, with such charges as 3drs. or 3½drs. of powder, and 1⅛oz. or 1¼oz. of shot, we may see the result in the records of Mr. Griffith's second crusher, which are as follows:

	Pressure at 2nd plug.	
12-Bore.	Black.	Schultze.
3drs. and 1⅛oz.	1796lb. per sq. in.	1910lb. per sq. in.
3½drs. ,, 1⅛oz.	2280 ,, ,, ...	2414 ,, ,,
,, ,, 1¼oz.	2021 ,, ,, ...	2684 ,, ,,

Thus the result of an experiment on the one-crusher system would make it appear as though the Schultze strain were greater than that from the Black powder, whereas the very reverse is the fact. By instituting a comparison of the highest pressures recorded by each powder, whichever crusher made the record, the results are found to be as stated in the table below. This shows, primarily, the greatest pressure indicated by each powder, and the number of the crusher which made that record (such number being put between parentheses); while the subsequent column for "Difference" shows how much per cent. the Schultze records are below those of Black.

	Highest Pressures.		Percentage of Difference.
12-Bore.	Black.	Schultze.	
3drs. and 1oz.	1910lb. (1)	1770lb. (2)	7 p.c. less.
,, ,, 1⅛oz.	2090lb. (1)	1910lb. (2)	9 ,, ,,
3½drs. ,, 1⅛oz.	2800lb. (1)	2414lb. (2)	14 ,, ,,
,, ,, 1¼oz.	3110lb. (1)	2684lb. (2)	14 ,, ,,
4drs. ,, 1¼oz.	3770lb. (1)	3120lb. (2)	17 ,, ,,
20-Bore.			
2drs. and ⅞oz.	2001lb. (1)	1323lb. (2)	34 p.c. less.
,, ,, ⅞oz.	2240lb. (1)	1488lb. (2)	34 ,, ,,
2½drs. ,, ⅞oz.	2542lb. (1)	1627lb. (2)	36 ,, ,,
,, ,, ⅞oz.	2925lb. (1)	1890lb. (2)	33 ,, ,,
3drs. ,, ⅞oz.	3520lb. (1)	2290lb. (2)	35 ,, ,,
,, ,, 1oz.	4050lb. (1)	2560lb. (2)	37 ,, ,,
3½drs. ,, 1oz.	5200lb. (1)	2960lb. (2)	43 ,, ,,

These figures support, in a remarkable degree, the conclusions at which we arrived as the result of our experiments, set forth in the *Field* nearly two years ago [see *ante*, page 26], relative to the great increase of strain in the 20-bore as compared with that in the 12-bore; but, although the lead cylinders showed clearly enough that a much larger amount of force was exerted in the one case than in the other, and also indicated where the greatest strain occurred, they did not furnish any key by which the amount of dilatation could be translated into pounds of pressure. Now, however, this deficiency is effectively overcome by the method worked out by Mr Griffith.

On comparing the charges stated in the foregoing table, it will be found that there is only one instance in which exactly the same quantity of powder and shot was used in both 12-bore and 20-bore, viz., 3drs. and 1oz. In the smaller bore the charge would necessarily extend to a greater length than in the other, and the increased resistance produced by the friction of the longer mass of shot would elicit a corresponding development of force in the powder. But there is a marked difference in such development when, on the one hand, there is a slow-burning powder like Schultze, which gradually pushes on the charge of shot before attaining complete combustion, and, on the other, a comparatively quick explosive like No. 4 Black, which attains its highest pressure before the shot gets under way; and this difference is well exemplified in the 12-bore and 20-bore records with 3drs. and 1oz. In the 12-bore, the pressure indicated by Schultze was 1770lb. per square inch; and this was raised to 2560lb. in the 20-bore, or an increase of nearly one half. With the Black, the 12-bore pressure was 1910lb. per square inch; but in the 20-bore it rose to 4050lb., or more than double the former strain. The urgent necessity of a more effective test of the strength of these small-bores, which have been so fruitful of mischief in the last few years, is thus rendered more apparent than ever, and fully warrants the steps which have at length been taken by the Proof-House authorities with the view of remedying the existing defect in their regulations.

But, although Black invariably shows a greater strain than Schultze at the first crusher-guage, and is likewise higher at the second in many instances, yet the reverse is the case at crusher No. 3, for here the higher pressures are, as a rule, recorded by Schultze. The decrease of force with both powders at this point (6in. from the breech) is already considerable, as compared with the highest strain previously exercised by each; but, as will be seen by the following figures, the falling off is greater in Black than in Schultze; and in the 20-bore Black's percentage of loss is much more marked than in the 12-bore.

	Reduction of Force at 3rd plug.	
12-Bore.	Black.	Schultze.
3drs. and 1oz.	1040lb., or 46 p.c. fall	1090lb., or 42 p.c. fall.
,, ,, 1⅛oz.	1046lb. ,, 50 ,, ...	1067lb. ,, 44 ,,
3½drs. ,, 1⅛oz.	1160lb. ,, 59 ,, ...	1222lb. ,, 49 ,,
,, ,, 1¼oz.	1228lb. ,, 61 ,, ...	1257lb. ,, 53 ,,
4drs. ,, 1¼oz.	1321lb. ,, 65 ,, ...	1352lb. ,, 56 ,,
20-Bore.		
2½drs. and ⅞oz.	1006lb., or 60 p.c. fall	1022lb. ,, 37 p.c. fall.
,, ,, ⅞oz.	1060lb. ,, 62 ,, ...	1046lb. ,, 45 ,,
3drs. ,, ⅞oz.	1171lb. ,, 67 ,, ...	1162lb. ,, 50 ,,
,, ,, 1oz.	1200lb. ,, 70 ,, ...	1226lb. ,, 52 ,,
3½drs. ,, 1oz.	1279lb. ,, 76 ,, ...	1322lb. ,, 55 ,,

Having thus given an explanation of the differences in amount of explosive force exhibited by black powder (No. 4) and Schultze, based upon figures copied from Mr. Griffith's record book, we will now add a few particulars with respect to the comparative results obtained by testing two other varieties of Black—the one being No. 6, which is used by some persons for their shot guns, but is more generally adopted for sporting rifles; and the other being what is known as "basket powder," which is small in grain, being between No. 2 and No. 3, but of a much higher specific gravity than the ordinary powders having grain of a similar size. We believe the basket powder was originally made by Messrs. Curtis and Harvey for Mr. Purdey, and is still used largely by the customers of that celebrated gunmaker; at all events, the sample used was obtained by us direct from his establishment, by his permission, for the purposes of experiment.

We have personally had an opportunity of seeing these powders tested, as we lately received from Mr. Griffith an invitation to visit the works of the Schultze Gunpowder Company, in Hampshire, in order to see his new crusher-gange in operation. And here we may remark, *en passant*, that these works contain the most perfect and complete set of instruments for carrying out experimental investigations connected with sporting guns, that it has ever been our fortune to meet with. The covered range, besides including such ordinary implements as targets, force-gauge, &c., is fitted up with electrical apparatus for ascertaining the velocity of the shot, and marking the regularity of arrival of the pellets at the target, while the laboratory contains various contrivances for testing the explosive force of gunpowders, such as the leaden cylinders adopted in our own investigations, and other methods with which Mr. Griffith experimentalised prior to carrying out his present arrangement; while his book of records contains a store of information, including not only particulars, ascertained by chronograph, of the time of flight of shot for distances from 10 yards to 60 yards, but also the time occupied from the fall of the trigger to the shot leaving the muzzle of the gun.

On going down to visit the works, we took with us several canisters of powder, including those above named and No. 4, all of Messrs. Curtis and Harvey's manufacture. Nine charges of each were loaded in exactly the same way, and fired in the 12-bore apparatus, so as to

obtain three records from each plug. The crushers are not all put in action together, Mr. Griffith having found that, when this is done, the force expended in producing the compression at the first plug lessens the amount recorded at the second; and he therefore tries them independently, so as to obtain a full record of pressure at each point.

The powders were not weighed, as a rule, but measured, so as to make the conditions more in accordance with those under which cartridges are ordinarily loaded. The charge was 3drs, as measured by Jones's Accuratus machine, but the first charge of each powder was weighed, in order to ascertain what was the variation produced by the difference in grain and density. It was found that the 3drs. measure of No. 6 weighed 88 grains; that an equal bulk of No. 4 weighed 84 grains; and that the same measure of basket powder weighed 87 grains. The Schultze was exactly half the weight of No. 4, or 42 grains. No 6 chilled shot (270 to the oz.) was used, the charge being 1⅛oz., or 304 pellets, counted by Greener's counting trowel. The cartridge cases were Eley's salmon-coloured; the wads those of the usual *Field* loading, viz., a 11¾ hard felt wad upon the powder, followed by a ⅜in. greased felt and a thin card, then the shot, and on that a thin card, upon which the case was moderately turned over.

Mr. Griffith suggested, before we had obtained any records that, owing to the state of the weather (we having, unfortunately, paid our visit on a very gloomy day, with almost continuous rain), the pressure exhibited on the gauges would, he had no doubt, be lower than was shown on fine dry days—at all events, as regards Schultze, though he could not speak with equal certainty with respect to Black. We found, however, when the figures were ascertained, that it applied to both so far as there were previous records for comparison, but affected Schultze rather more than C. & H. No. 4. The average pressures per square inch, at the respective plugs, with the four kinds of powder, were as follows:

	1st plug.	2nd plug.	3rd plug.
No. 6	14781b.	13391b.	9001b.
No. 4	19541b.	16141b.	10321b.
Basket grain	29001b.	20971b.	11111b.
Schultze	16951b.	16631b.	10361b.

We should have been very glad to test some proof-powder also, had it been possible to obtain any; but having recently made a formal application to the Proof-House authorities of Birmingham, requesting to be supplied with a sample, and our request having been declined by them, we could do no more; and any inferences as to its strength must be drawn, so far as we are now concerned, from the results ascertained by testing C. & H. No. 6.

The existing rule as to proof-powder is, that it shall be of equal quality and strength with that used by Her Majesty's War Department; and in the new regulations proposed by the Proof-House authorities this definition has been allowed to remain unaltered. The powder employed by Government in proving the Martini-Henry rifle is of the same kind as that which is given to the troops for use in that weapon, viz., R.F.G.^{2}. Common sense tells us that the gun of the sportsman should be treated in the same way, and be proved with the powder which is likely to be used by him. R.F.G.^{2} is an excellent powder for its especial purpose; but that does not make it the best for other purposes. According to the evidence given at Birmingham Assizes by the manager of the gunpowder works of Messrs. Curtis and Harvey, who manufacture R.F.G.^{2} for the Government, this powder is practically the same as C. & H. No. 6. The latter explosive was originally recommended by the

No. 6.
(Pressure, 14781b.)

No. 4.
(Pressure, 19541b.)

Basket.
(Pressure, 29001b.)

committee on the Martini-Henry rifle as most suitable for that weapon, a slow-burning powder of even grain being required; but, the No. 6 being very expensive to make, the Government authorities at Waltham Abbey adopted their own corning arrangements and the sieves they already had in use; hence the grain is not so even as No. 6, but answers as well for army purposes. The question then arises whether it is equally suitable for the proof of sporting guns.

We look at three crusher-gauges that have undergone the compression made by No. 6 powder at the 1st plug; we pile them one upon another, place them alongside similar piles of leads crushed by two other powders that are commonly used by sportsmen, and we ask, Is it not obvious to the eye that a very different amount of force is exerted by the three powders? And ought the weakest of the three to be employed in testing the guns that are to be used with the strongest? The records show that the strain from No. 4 is more than 30 per cent. higher than that from No. 6; and with the "basket powder" the pressure is very nearly doubled. W.—T.

[Since the above article was printed, various alterations have been made in the proof regulations; and the new Rules of Proof are given *verbatim* at the commencement of this book, pp. 1 to 8.]

POWDER PRESSURES AT DIFFERENT PARTS OF THE GUNBARREL.

(*Field*, June 1, 1895; vol. 85, p. 757.)

REPORTS of experiments have been published in the *Field*, from time to time, which demonstrate that some powders produce much more stress in the chamber of the gun than do other powders which give equal or even higher velocity to the shot. Nevertheless, correspondents occasionally write to say that they prefer powders which give a good high pressure, as without such pressure there would not, in their opinion, be sufficient killing power imparted to the shot; and so birds would go off wounded, and die miserably, instead of being properly brought to bag. Those who make such contentions, however, evidently overlook the fact that the killing force depends upon the speed of the pellets when they reach the game; and that the velocity of the shot is not necessarily enhanced by excessive strain in the barrel.

Other correspondents have occasionally written to complain that, owing to a change of powder, they have had favourite guns burst which they have used for many years with some other kind of explosive; and we have not unfrequently found, on examining such guns, that the barrel was broken half-way or two-thirds the distance down the tube, where the metal was very thin—but was not at all injured near the breech, where the strain would be greatest and where the the metal is thick. It is not very surprising that such guns should occasionally succumb—supposing that a change has been made from a quick-burning powder, that gives a great amount of stress at the breech, but little at the muzzle; whereas the substituted powder may give a more equable pressure throughout.

Some of the old guns used to be made excessively thin at one part of the barrel, and less thin a little further on, so as to ensure expansibility at a given point, with contraction beyond, and thus to obtain improvement in pattern. The effect produced was somewhat similar to that obtained by the modern choke-boring, though less in degree; it was, in short, a kind of "recess-choke." Supposing the owner of such a gun, which he had used for many years with No. 2 powder, had been impressed by symptoms of wear-and-tear in his old favourite, he might not unnaturally think he would do well to substitute a less powerful explosive; and hence he might select No. 6 black, or some nitro-compound which was said to give less pressure in the gun. Such change, however, might possibly have the very opposite effect to that which he anticipated. The continued friction of shot, in its passage through the gun, would wear away the metal at the thinnest part in much greater proportion than at the thicker parts of the barrel; and the removal of a thousandth part of an inch at this thin point would have considerably greater effect than removing a similar amount elsewhere. Nevertheless, the barrel might still be strong enough to withstand the gas-pressure of No. 2 powder, which greatly diminishes in force towards the muzzle; whereas, if a slower burning powder be substituted, the stress, although lessened at the breech, would be increased towards the muzzle; and, consequently, the old favourite gun might be burst, simply owing to its owner's well-meant act of precaution.

Some time ago we were asked whether the records of our experiments would furnish any reliable formula that might serve as a guide to gunmakers by indicating where it would be desirable to thicken the barrels of guns, in order to withstand the severe strains which are at times produced by the use of nitro powders. It is scarcely possible, however, to lay down any one general principle that shall apply alike to all varieties of powder, because different explosives have separate idiosyncrasies; and what may hold good with one variety will not be equally applicable to another. We showed, a few months ago, that there is such very wide variation in the behaviour of divers explosives,

when extraordinary charges are used, that it is hopeless for any gunmaker to attempt to provide against every contingency which may arise from the acts of folly or ignorance perpetrated by inexperienced loaders of cartridges. Our present purpose, however, is not connected with the risks arising from careless loading and excessive charges. We now propose to show the variations in amount of force developed, at different parts of the gunbarrel, when cartridges are properly loaded with divers kinds of powder; and, by comparing these pressures with those produced by the official proof-charge (to which all guns must be submitted before they are sold in this country) an idea may be formed of the margin of safety that lies between the test which guns have already undergone and the amount of stress which they would be likely to undergo afterwards in the course of ordinary use.

In order to indicate more thoroughly the nature of the various explosives, and the parts of the barrel where stress chiefly occurs, we have recently carried out certain experiments, in which we have tested, by means of a new 12-bore crusher-gauge, the pressures exhibited by different powders at different points in the barrel. This crusher-gauge enables us to take pressures at six places; viz., the first plug is at 1in. from the breech; the second at 2½in., or end of the ordinary cartridge case; the third at 6in.; the fourth at 12in.; the fifth at 18in.; and the sixth at 24in.; while the muzzle velocity, at 30in., was also ascertained by chronograph. We did not place a crusher-plug nearer the muzzle than 6in., because we did not think it would give reliable results, as the charge would probably have left the barrel before the crusher-gauge had time to act. The records of pressure and velocity were not taken simultaneously, as some amount of force is expended at each point by the crushing of the lead in making the record; consequently, every pressure had to be taken separately; and thus there were thirty-six rounds of each powder fired to obtain the averages of the crusher-gauge records; and besides these were the rounds required for ascertaining the muzzle velocity, which was taken by an electric screen stationed at 5 yards from the muzzle of the gun.

The gun used for the velocities was our ordinary experimental 12-bore, of which the choked barrel alone was employed. The charge of shot throughout was 1½oz. of No. 6 chilled (270 pellets per oz.), with the usual wads; and the weight of powder was varied, as stated in the tables, so as to secure an average of about 1220 ft.sec., which corresponds, as nearly as possible, with a mean velocity of 850 f.s. for a range of 40 yards.

The records obtained in these experiments are stated in the accompanying tables. The results are also shown graphically in the two diagrams of curves given herewith. The first is confined to black powders; and, besides showing the pressures given by three kinds used for sporting purposes (Nos. 2, 4, and 6 grain), it also shows the amount of stress given throughout the barrel by the definite proof-test of 6½drs. of the official proof powder, with 1⅛oz. of No. 6 shot. The curve of the proof-charge is represented by the topmost dotted line; that of No. 2 by a thin black line; No. 4 and No. 6 by broken lines, distinguished by variations in the dots and dashes which represent the curves. The second diagram is devoted to four varieties of nitro powders, differing somewhat in type (viz., Schultze, Walsrode, Ballistite, and Cannonite). We have not thought it requisite to include E.C., S.S., and some others of the older type of nitro powders, as their characteristics are so much alike that it would be confusing, rather than otherwise, to attempt to distinguish between the whole of them.

Taking first the black powders, it will be seen that 72grs. of the quick-burning No. 2 sufficed to produce the standard muzzle velocity; whereas 10grs. more (or exactly 3 drams) of No. 4 grain were required to give a similar result; and of the slower-burning No. 6, a further increase of two grains was requisite.

Looking at the first diagram of curves, it will be observed that the pressure near the breech rises much higher with No. 2 than with either No. 4 or No. 6 powder; but at 10in. from the breech all are nearly at the same level. Beyond 8in. the pressure with No. 2 drops below the others, and it continues the lowest up to the muzzle of the gun. On the other hand, the powder of coarsest grain, being slowest in combustion, gives at the breech, with a charge of 84grs., barely two-thirds the amount of pressure exhibited by 10grs. less of No. 2; whereas, at the third plug, No. 6 shows the highest pressure; and at the last plug its force is double as great as that of the finest grain. Yet all three powders (with the charges stated) give practically the same muzzle velocity. It will further be observed that a wide margin of safety lies between the curve of the proof-charge and the strongest of the sporting powders. The apex of No. 2 black rises to 3½ tons; while that of the proof-charge is 4½ tons, or 35 per cent. more. And with the other two black powders there is a much wider margin—the proof-test showing nearly double the stress of No. 4, and more than double that of No. 6, at the breech; while the differences towards the muzzle are still more marked.

Of the nitro-compound powders, Ballistite showed the nearest resemblance in pressures to the fine-grain black explosive. At the breech its stress is about 15 per cent. lower than that of No. 2, and at the last plug it is 2 per cent. higher; while the muzzle velocity is practically identical, being 1230 f.s. with the one, and 1232 f.s. with the other, on the average of six rounds; though the black powder was less variable from round to round. Cannonite, on the other hand, showed the nearest resemblance to No. 6, in maintaining a strong pressure up to the end of the barrel. But Schultze was very little behind in this respect, though it gave the lowest stress at the breech. Walsrode, with the new special Eley cases, showed considerably less stress in the chamber than it had done with previous cases made by the same firm. Indeed, with the exception of Ballistite, all the nitro powders showed less stress in the chamber than any of the black powders, and a more highly-sustained pressure towards the muzzle than either No. 2 or No. 4 black. We may here mention that the three black powders and Schultze were loaded in Eley's ordinary green cases; but Walsrode, Ballistite, and Cannonite all had special cases, made expressly for them by the same firm.

Of course, the powders which, like No. 2 black and Ballistite, give the greatest amount of stress in the chamber, must also drive the shot out of the barrel in the shortest space of time; but, with equal muzzle velocities, this does not affect the speed with which the shot traverses the distance between gun and bird.

How the rate of combustion in the chamber operates may be seen by some records which were published in the *Field* several years ago, showing the fractions of time taken to traverse various distances, 3in. or 6in. apart, from the breech to the muzzle of the gun. On another occasion we published records of muzzle velocities which were obtained by gradually cutting down a gunbarrel from 34in. to 10in. in length; and these likewise serve to further explain the diagrams of curves which we now give. The records of time, however, being given in fractions extending to six decimals, were not easily comprehended at a glance; and therefore, in order to utilise the information more effectually, we have now converted the fractions of a second for a few inches into velocities of feet-per-second, which make more apparent the peculiar characteristics of the respective powders.

The results, with three black powders and one nitro compound, are given in the following short table, which shows the rate of speed imparted to the shot in the first 3in. and the second 3in. of the barrel; and then at subsequent intervals of 6in. each. The charges of powder then used, not being intended to produce equal muzzle velocity, were equal with black (viz. 3drs.), and the ordinary equivalent for 3drs. (42grs.) with Schultze.

	Velocities, in feet per second.				
Powders.	3 inches.	6 inches.	12 inches.	18 inches.	24 inches.
No. 2 Black, 32grs.	238	543	870	1052	1333
No. 4 ,, 32grs.	198	480	800	1000	1235
No. 6 ,, 32grs.	156	439	775	893	1118
Schultze, 42grs.	88	568	909	1087	1296

In the first three inches, the time of ignition is necessarily included; so that the quick-burning No. 2 is seen much in advance of the other black powders, and especially so as compared with the nitro powder. The fineness of grain facilitates combustion; and the rapid decomposition of the powder sets free a greater body of gases in a given time; while the pressure of these gases produces a great amount of stress in the chamber of the gun, as is indicated by the suddenly-rising high curve shown in the first diagram. And the greater amount of resistance offered to expansion of gases—as by increasing the weight of the shot charge, or giving more turnover to the cartridge case—the higher would be the apex of the curve.

The potential force of gunpowders is something marvellous, in comparison with which the difference of pressure between quick and slow powders is "a mere fleabite." The potential force of No. 6 grain is the same as that of No. 2 grain, supposing that sufficient restraint be given to develop the full power of each. No. 6, as shown in the diagram, gives in a 12-gauge smoothbore an average pressure of about 2½ tons per square inch; but in the Martini-Henry rifle, where resistance to the movement of the projectile is greater, the same powder would give a pressure of about 5 tons; in the ·303 rifle, where resistance is very greatly increased, the pressure of the solid black pellets rises to about 18 tons per sq. in.; but the full potential force is more than double this; for Sir F. Abel found (as stated in the "Philosophical Transactions of the Royal Society") that the full pressures of black gunpowders is over 40 tons per sq. in., when they are tightly shut up in closed chambers which admit of no expansion whatever. This, too, it should be remembered, is independent of the weight of the charge, so long as the closed chamber is thoroughly filled and strong enough to stand the stress. With some of the nitros, we have heard, the pressure rises to over 60 tons per sq. in. One may understand, therefore, the possible effect of the resistance produced

CRUSHER GAUGE PRESSURES WITH SIX PLUGS.

72grs. of No. 2 Black, 1¼oz. of No. 6 shot.

1st plug, distance from	Tons. per square inch.						Average.
breech, 1in. ...	3·34	3·30	3·20	3·28	3·32	3·26	= 3·28
2nd plug, 2½in....	2·70	2·43	2·55	2·64	2·64	2·67	= 2·61
3rd plug, 6in. ...	1·29	1·29	1·35	1.29	1·35	1·29	= 1·31
4th plug, 12in. ...	·85	·82	·85	·85	·83	·85	= ·84
5th plug, 18in. ...	·50	·42	·42	·42	·43	·43	= ·44
6th plug, 24in. ...	·20	·20	·20	·20	·20	·20	= ·20

82grs. of No. 4 Black, 1¼oz. of No. 6 shot.

	Tons per square inch.						Average.
1st plug, breech.	2·28	2·26	2·24	2·28	2·28	2·31	= 2·28
2nd plug, 2½in....	2·12	2·00	2·04	2·00	1·92	1·88	= 1·99
3rd plug, 6in. ...	1·29	1·22	1·22	1·22	1·29	1·29	= 1·26
4th plug, 12in. ...	·96	·88	·88	·92	·91	·93	= ·91
5th plug, 18in. ...	·64	·43	·64	·57	·57	·58	= ·57
6th plug, 24in. ...	·23	·21	·32	·32	·31	·21	= ·27

84grs. of No. 6 Black, 1¼oz. of No. 6 shot.

	Tons per square inch.						Average.
1st plug, breech.	2·16	2·12	2·08	2·12	2·16	2·04	= 2·11
2nd plug, 2½in....	2·04	2·08	2·16	2·08	2·12	2·04	= 2·09
3rd plug, 6in. ...	1·47	1·58	1·58	1·47	1·58	1·58	= 1·53
4th plug, 12in. ...	·96	·93	·93	·95	·95	·95	= ·95
5th plug, 18in. ...	·64	·57	·57	·50	·57	·60	= ·58
6th plug, 24in. ...	·37	·46	·42	·37	·42	·37	= ·40

MUZZLE VELOCITIES, in feet per second (with 1¼oz. of No. 6 shot).

Black Powders:						Averages.
No. 2 C. & H., 72grs.	1234	1224	1244	1219	1234	1224 = 1230
No. 4 ,, 82grs.	1234	1219	1219	1214	1234	1221 = 1222
No. 6 ,, 84grs.	1224	1233	1244	1220	1231	1222 = 1229

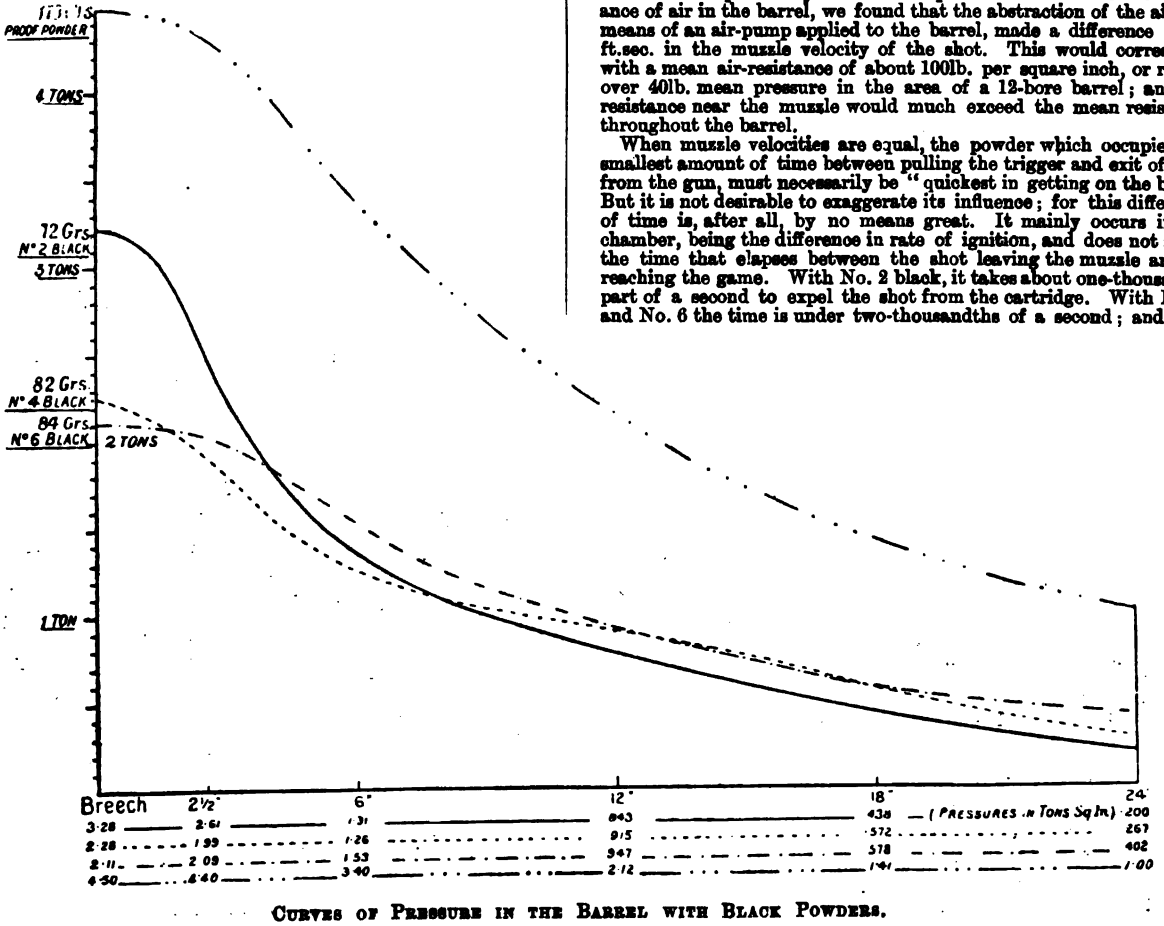
by an excessive amount of turnover in a cartridge case, whether it is loaded with black or with nitro powder.

For a graphic representation of the nitro powders, reference must be made to the second diagram; but the figures in the above brief table show that, to move the shot-charge the first 3in., Schultze took about three times as long as the fine-grained black powder, and nearly twice as long as No. 6. When, however, a nitro powder is once thoroughly ignited, its decomposition proceeds more rapidly than that of a black explosive. Hence it will be seen in the table that, between 3in. and 12in., the Schultze rate of increase was greater than that of either black powder. And the curves in the diagram show that, at subsequent points, some powders, both black and nitro, give more sustained pressure in the barrel than those which exhibited such sudden stress in the chamber. It will not be at all surprising, therefore, that a gun which is very stout at the breech, and very light forward, should be able to withstand the stress of No. 2 powder at both points, yet should nevertheless succumb with No. 6 black, or a nitro, that gives more pressure near the muzzle, where the tube is thin, though less stress at the breech, where there is plenty of substance.

It will be observed in the table (page 33) that some velocities in the 24in. column are excessively high. We think, however, that the times in the barrel near the muzzle were somewhat vitiated by compression of air in the tube; so that the chronograph may have been put into action by the condensed air before the shot actually reached the point in question. This would appear to be the case from the fact that, although the records taken outside our shortened barrel accord pretty closely with the times taken inside the full-length barrel, for distances between 10in. and 18in., yet there were considerable differences beyond 18in., and the differences increased with the length of the barrel.

It may possibly be thought that the air could hardly be sufficiently compressed to produce such an effect. We may mention, however, that when we previously tried some experiments relative to the resistance of air in the barrel, we found that the abstraction of the air, by means of an air-pump applied to the barrel, made a difference of 40 ft.sec. in the muzzle velocity of the shot. This would correspond with a mean air-resistance of about 100lb. per square inch, or rather over 40lb. mean pressure in the area of a 12-bore barrel; and the resistance near the muzzle would much exceed the mean resistance throughout the barrel.

When muzzle velocities are equal, the powder which occupies the smallest amount of time between pulling the trigger and exit of shot from the gun, must necessarily be "quickest in getting on the bird." But it is not desirable to exaggerate its influence; for this difference of time is, after all, by no means great. It mainly occurs in the chamber, being the difference in rate of ignition, and does not affect the time that elapses between the shot leaving the muzzle and its reaching the game. With No. 2 black, it takes about one-thousandth part of a second to expel the shot from the cartridge. With No. 4 and No. 6 the time is under two-thousandths of a second; and with



Curves of Pressure in the Barrel with Black Powders.

CRUSHER GAUGE PRESSURES WITH SIX PLUGS.

32grs. of BALLISTITE, 1½oz. of No. 6 shot.

	Tons per square inch.					Average.
1st plug	2·58	2·82	3·12	2·55	3·00	2·70 = 2·80
2nd plug	2·49	2·20	2·28	2·24	2·12	2·00 = 2·22
3rd plug	1·15	1·22	1·29	1·22	1·22	1·29 = 1·23
4th plug	·78	·85	·82	·78	·82	·78 = ·81
5th plug	·20	·42	·32	·42	·33	·33 = ·33
6th plug	·20	·20	·26	·20	·20	·20 = ·21

34grs. of WALSRODE, 1½oz. of No. 6 shot.

	Tons per square inch.					Average.
1st plug	2·24	2·40	1·83	1·92	2·00	2·04 = 2·07
2nd plug	1·92	2·34	2·24	1·78	1·78	1·92 = 1·99
3rd plug	1·22	1·35	1·35	1·22	1·35	1·29 = 1·30
4th plug	·82	·91	·98	·91	·85	·95 = ·90
5th plug	·50	·64	·50	·50	·57	·57 = ·55
6th plug	·37	·20	·26	·32	·26	·26 = ·28

38grs. of CANNONITE, 1½oz. of No. 6 shot.

	Tons per square inch.					Average.
1st plug	1·41	2·08	1·83	1·88	2·00	2·08 = 1·88
2nd plug	1·58	1·22	2·00	1·47	1·41	1·35 = 1·51
3rd plug	1·29	1·35	1·35	1·35	1·29	1·29 = 1·32
4th plug	·85	·88	·98	·95	·91	·95 = ·91
5th plug	·64	·54	·50	·57	·54	·57 = ·56
6th plug	·42	·32	·37	·37	·37	·32 = ·36

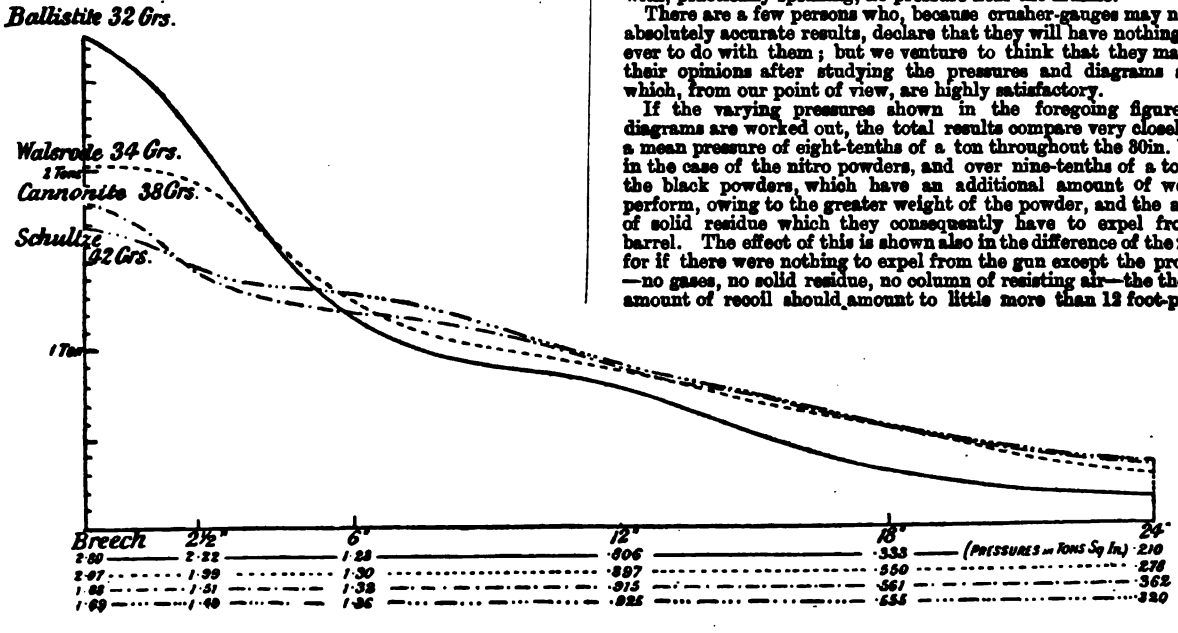
42grs. of SCHULTZE, 1½oz. of No. 6 shot.

	Tons per square inch.					Average.
1st plug	1·63	1·73	1·78	1·68	1·63	1·68 = 1·69
2nd plug	1·47	1·35	1·58	1·78	1·41	1·35 = 1·49
3rd plug	1·47	1·29	1·35	1·41	1·35	1·29 = 1·36
4th plug	·93	·88	·98	·95	·93	·91 = ·93
5th plug	·54	·57	·57	·57	·50	·56 = ·55
6th plug	·33	·33	·32	·32	·33	·33 = ·33

MUZZLE VELOCITIES, in feet per second (with 1½oz. of No. 6 shot).

NITRO POWDERS:

BALLISTITE, 32grs.	1219	1234	1264	1242	1212	1239 = 1232
WALSRODE, 34grs.	1196	1234	1214	1244	1249	1205 = 1224
CANNONITE, 38grs.	1234	1187	1194	1212	1244	1219 = 1215
SCHULTZE, 42grs.	1214	1214	1264	1239	1224	1164 = 1220



CURVES OF PRESSURE IN THE BARREL WITH NITRO POWDERS.

Schultze it is nearly three-thousandths. Supposing, then, that several cartridges (giving the same muzzle velocity) were fired at birds flying at the rate of 40 miles an hour, No. 6 powder would take, say, one-thousandth of a second longer than No. 2; and in that space of time the bird would be able to fly nearly three-quarters of an inch. Schultze would take, say, two thousanths of a second longer than No. 2 black; and consequently the bird would be able to fly nearly an inch and a half in the interim. Seeing what is the spread of the shot charge, it would be interesting to know what difference of aim would have to be made for birds at 20, 40, or 60 yards.

ESTIMATION OF PRESSURES FROM VELOCITIES.

We have often been asked the question, "What is the amount of pressure which must act throughout a 30in. barrel in order to impart, say, 1½oz. of shot in a 12-bore gun, the usual muzzle velocity of, say, from 1200 to 1300 feet per second?" To enable us to answer the question, we use the following formula:

$$\frac{W \times V^2}{A \times L \times 2240 \times 2g}$$

Here W represents the weight of the shot-charge in lb. or the fraction of a lb.; V^2, the velocity squared; A, the area of the bore in square inches or the fraction of a square inch; L, the length of the barrel in feet; 2240, the number of lb. in a ton; and $2g$ twice the accelerating force of gravity, which is 64·4 feet per second. The answer will be given in tons per square inch.

Now, for example, we will take an ordinary 12-bore 30in. barrel gun, using 1½oz. of shot. In order to obtain a muzzle velocity of, say, 1225 ft.sec., the pressure that must act through the length of the barrel is as nearly as possible seven-tenths of a ton per square inch.

This calculation gives the *mean* pressure that must be imparted to the charge of shot throughout the full length of the barrel, without taking into account any loss through friction and the ejection of the column of air in the barrel.

When we have given the above information to our inquirers, we have been asked why it is that pressures at the breech are often two, three, or more tons, when such a comparatively small pressure, acting through the whole length of the barrel, would do the necessary amount of work.

This question we must, for the most part, leave the powder manufacturers and the cartridge-case manufacturers to answer; but, of course, it would never do to have the same pressure acting from breech to muzzle, because the forepart of the barrels would have to be made very clumsy and heavy, in order to withstand the full stress there. There is no reason, however, as far as we can see, why the pressure should be three tons or more at the breech end of a gun, with, practically speaking, no pressure near the muzzle.

There are a few persons who, because crusher-gauges may not give absolutely accurate results, declare that they will have nothing whatever to do with them; but we venture to think that they may alter their opinions after studying the pressures and diagrams shown, which, from our point of view, are highly satisfactory.

If the varying pressures shown in the foregoing figures and diagrams are worked out, the total results compare very closely with a mean pressure of eight-tenths of a ton throughout the 30in. barrel, in the case of the nitro powders, and over nine-tenths of a ton with the black powders, which have an additional amount of work to perform, owing to the greater weight of the powder, and the amount of solid residue which they consequently have to expel from the barrel. The effect of this is shown also in the difference of the recoil; for if there were nothing to expel from the gun except the projectile—no gases, no solid residue, no column of resisting air—the theoretic amount of recoil should amount to little more than 12 foot-pounds,

whereas, in fact, it amounts to about double as much with the nitres (varying with the weight of the charge), and nearly three times as much with the black powders.

It is impossible that the gas pressure in a gun should act in the best possible way from every point of view; because if it acted in the best way in one direction, it would not be satisfactory in another. If we consider the question of the propulsion of a charge of shot from a gun, and wish to obtain the greatest economy of powder charge, small energy of recoil, and least noise of discharge, we should employ a powder which gives a very high initial pressure at the breech, gradually expanding down to an exceedingly low pressure at the muzzle. But when we desire the gun before all things to give good regular shot-patterns—in which case it is highly desirable that the pellets should not be crushed out of shape—we shou'd then use a powder which gives a uniform pressure from breech to muzzle. But by employing these means we should have to use a larger amount of powder; there would be more noise, and greater energy of recoil; and the barrel of the gun would have to be made the same strength from breech to muzzle. If these conditions could be carried out, no doubt very excellent shooting would be obtained, as the principal factor in producing poor patterns and irregular shooting is the use of powders which give very high initial pressures; thereby causing the shot to "ball" by crushing the pellets out of shape and making them adhere together.

In short, we may, on the one hand, use a powder that will give very high initial pressure and very low muzzle pressure. Such powder will give high velocities and comparatively little energy of recoil, but the shot patterns will not be very good, and the breech of the gun must be made exceedingly strong. On the other hand, we may use a very slow-burning powder, that, while imparting an equal muzzle velocity, will give a more uniform pressure from breech to muzzle. In this case, the gun may have much less metal at the breech, but must be heavier forward. There will be greater energy of recoil, although it will be more in the nature of a push than a blow, and therefore not be so unpleasant to the shooter; and the shot patterns will be good and even.

There is also another matter which has to be considered, and that is the tendency to hang fire. If the initial pressure were only seven-tenths of a ton, it would be less than half the initial pressure of Schultze, and only about one-fourth as great as that of No. 2 black. It has been shown above, that the rate of movement of the shot-charge, in the first three inches of the barrel, is with Schultze about one-third as fast as with No. 2. And a corresponding diminution, with a powder giving only seven-tenths of a ton pressure, would amount to a veritable hang-fire. Schultze nearly makes up the loss of time in 3in. by having greater speed than No. 2 at 6in; but that compensation could not occur with a powder which gave uniform pressure throughout; for with such uniform force the gain in velocity would chiefly occur towards the end of the barrel. How far the different powders vary in this respect will be seen by records of velocity which we ascertained several years ago by cutting down a barrel gradually from 34in. to 10in. The chronographic records were published in the *Field* of Aug. 29, 1891, from which we extract a few particulars, and append thereto the theoretic velocities of an even-pressure powder producing similar speed in a 30in. barrel.

	Velocities, in feet per second at							
	10 inches.		22 inches.		26 inches.		30 inches.		34 inches.
No. 2 Black	913	.....	1075	.....	1115	.....	1123	.....	1147
No. 4 Black	798	.....	1046	.....	1089	.....	1114	.....	1122
Schultze	838	.....	998	.....	1075	.....	1113	.....	1119
E.C.	782	.....	964	.....	1023	.....	1106	.....	1120
S.S.	823	.....	991	.....	1016	.....	1110	.....	1162
Theoretic powder, equal pressure	647	.....	959	.....	1043	.....	1120	.....	1192

If a mild cap is used, the pressure at the breech may be greatly lessened, and the mean pressure may be compensated for by a slight increase in powder. This additon to the powder-charge will raise the pressure towards the muzzle, while the initial stress in the chamber will nevertheless remain comparatively low.

If, on the other hand, a strong cap or a very quick powder be used, the velocity of the shot would not be increased in the same ratio as the pressure. To double the speed in the first three inches, or any other given length of barrel, the stress would have to be quadrupled. Indeed, that rate of increase would be required even supposing the pressure to be uniform; and when the increase of stress occurs only in the chamber, and the pressure afterwards rapidly dwindles away, the ultimate speed of the projectile may even be diminished, owing to the increase of friction and air-resistance in the barrel.

Between extremes the proper path lies; and we leave it to those whose business it is to manufacture explosives and make cartridge-cases to clear the course which shall give most satisfaction to the general body of their clients. P.—T.

THE "FIELD" CRUSHER-GAUGE RECORDS.

(*Field*, July 6, 1895; vol. 86, p. 4.)

SIR,—To clearly understand your interesting experiments about gas pressure in the gun-barrel, it would be necessary to know exactly the manner in which the scales of pressures are elaborated.

I suppose that you make use of the printed scales supplied by Cogswell and Harrison with their pressure apparatus, the said scales including the remaining length of small leads, from ·494in.=1·00 ton to ·350=4·90 tons; large leads, from ·482=4·00 tons to ·360=12·00 tons; and copper crushers, from ·473=11·00 tons to ·359=30·00 tons.

In the *Field* I cannot find direct information about the subject; but some "Notes on Shooting Problems" in your issue of April 21, 1888, lead me to think it probable that the whole system of measuring is worked out by Mr. Griffith. But the tables given in the "Notes" by this versed expert seem to be other than the printed tables of Cogswell and Harrison; so I must believe that you are now experimenting with a crusher apparatus, the plugs of which have a widely different diameter from that stated in those notes, vis., ·618in.

To elucidate this somewhat intricate matter, it surely would be a boon to many of your readers if you would explain *ab ovo* the manner in which your results now have been obtained—*i.e.*, in what way the numbers of the scales have been worked out.

If you have no time to commit yourself to a more detailed explanation, I would be satisfied by some statements through your columns, vis.: (1) What diameter have the plugs of your crusher apparatus now in use? (2) Are the printed tables worked out by means of dead weight, or by means of dropping weights? And, in the case of the former, how long is the time of acting of the dead weight on the leads?

MAJOR THIEL.

Berlin, June 25, 1895.

[The crusher-gauges employed in our experiments were made for us by Messrs Cogswell and Harrison, and similar ones may be seen in the workshops of that firm, who will doubtless give every information, with respect to method of working, that may be desired by those who are interested in the subject. In principle they resemble those which are used by Her Majesty's War Department, and by many foreign Governments, for the purpose of testing military arms, but with such differences of detail as are necessary to adapt them to the special requirements of sporting guns. The crusher-gauge designed by Mr. R. W. S. Griffith (and alluded to in Major Thiel's letter) was, we believe, the first that was made for sporting guns (at all events, we had not previously heard of one); and it was described in the *Field* of Nov. 20, 1886 [and here reprinted, p. 29]. Since then many experiments have been carried out by Mr. Griffith and others, some of which, with dead weights for various periods of time, and others with dropped weights, were mentioned in the *Field* of April 21, 1888, alluded to by Major Thiel. Some little time, we believe, after Mr. Griffith had had his apparatus in use, Messrs Cogswell and Harrison made their crusher-gauge, which is similar in principle to Mr. Griffith's, but the plug or piston that receives the gas-pressure, and the metal cylinders which record it, are of smaller dimensions; and we adopted this latter apparatus in preference, as being, in our opinion, somewhat more sensitive to variations in pressure than the former. This smaller apparatus has likewise been adopted by Mr. Griffith, and he uses it, whenever necessary, in addition to that made from his original design. For factory purposes, where direct comparison is requisite between the pressures given by samples of powder now in process of manufacture, and the old records that have been given by samples made in former years, the original apparatus is still constantly used; but for the ordinary pressures of the gun-charge he prefers the smaller crusher-gauge such as we always employ.

The area of the steel plugs or pistons, in all the crusher-gauges in our possession, is uniformly $\frac{1}{11}$th of a square inch; but the recording cylinders vary in size and material according to the intensity of the force which has to be recorded—it having been found that no kind of crusher would, unless altered in some respect, give equally reliable records of very high and very low pressures. Accordingly, for the high pressures stated in the *Field* of June 22, 1895, we used solid copper cylinders of ·250 inch in diameter and ·500 inch in length. These give records from 30 tons down to 11 tons per square inch. From 12 tons down to 4 tons we use lead cylinders of larger size, viz., ·500in. diameter and ·500in. length. It will thus be seen that the scale for the copper cylinder, and for the larger lead cylinder, overlap one another; so that if doubt should arise as to the accuracy of any particular record near the point of junction, it can be tested by both methods; but, as a rule, the results obtained are practically the

same. From four tons down to one ton the pressures are taken by smaller cylinders of lead, viz., ·323in. diameter and ·500in. long; and here again the two kinds overlap, so that between four and five tons both methods may be employed. For pressures below a single ton, still smaller leads are used, viz., ·200in. diameter and ·280in. long. We have heard of hollow copper cylinders being used, the walls of which are made more or less thick to meet the required degree of sensitiveness; but we have not ourselves used these hollow cylinders, being satisfied with the results we already obtain.

For the accuracy of the printed scales of pressures sent out with Messrs. Cogswell and Harrison's apparatus we alone are responsible. They represent the results of a very long series of experiments, extending over many months, which we carried out expressly for the purpose of working out reliable pressures; and we supplied Messrs. C. & H. with copies of a numerical table that we had had printed for our own use. That printed table (a copy of which is given below on this page), however, does not contain a scale for pressures that are below one ton, as, at the time when that table was printed, our present scale for very light pressures did not exist. It has since been framed especially for the experiments reported in the *Field* of June 1, 1895 (and here reprinted on pp. 34-35), as leads of ·313in. diameter are not sufficiently sensitive to record the very low gas pressures which occur near the muzzle of the gun. The following is the supplementary scale of pressures for these very small leads:

SCALE OF PRESSURES FOR SMALL LEADS of ·200" diameter and ·280" length.

Remaining Length.	Pressure per square inch.	Remaining Length.	Pressure per square inch.
·278"	0·200 ton	·269"	0·819 ton
·277	·220 "	·268	·858 "
·276	·420 "	·267	·898 "
·275	·504 "	·266	·910 "
·274	·575 "	·265	·924 "
·273	·636 "	·264	·955 "
·272	·690 "	·263	·973 "
·271	·738 "	·262	·986 "
·270	·781 "	·261	1·000 "

With the copper as well as with the lead cylinders, the scale is based on the application of a dead weight pressure for a very brief period of time. In some of the old scales of pressure, formerly in vogue, the weight was allowed to rest on the lead for hours together. But this necessarily gave an incorrect representation of the facts, as a comparatively light weight, acting for a long period, will crush the lead as much as a heavier weight acting for only a short time; and the pressure inside a gun continues but for a very small fraction of a second. We could not, of course, put on and take off the pressure quite so rapidly as occurs in the gun itself; but we imitated the

SCALE I.

SMALL LEAD CRUSHERS

("·323" diameter, and "·500" length).

Remaining Length.	Pressure per sq. inch.	Remaining Length.	Pressure per sq. inch.	Remaining Length.	Pressure per sq. inch.
·499		·449 = 2·68 tons		·399 = 3·92 tons	
·498		·448 = 2·91 "		·398 = 3·94 "	
·497		·447 = 2·94 "		·397 = 3·96 "	
·496		·446 = 2·97 "		·396 = 3·98 "	
·495		·445 = 3·00 "		·395 = 4·00 "	
·494 = 1·06 tons		·444 = 3·02 "		·394 = 4·02 "	
·493 = 1·08 "		·443 = 3·04 "		·393 = 4·04 "	
·492 = 1·15 "		·442 = 3·06 "		·392 = 4·06 "	
·491 = 1·23 "		·441 = 3·08 "		·391 = 4·08 "	
·490 = 1·23 "		·440 = 3·10 "		·390 = 4·10 "	
·489 = 1·26 "		·439 = 3·12 "		·389 = 4·12 "	
·488 = 1·41 "		·438 = 3·14 "		·388 = 4·14 "	
·487 = 1·47 "		·437 = 3·16 "		·387 = 4·16 "	
·486 = 1·52 "		·436 = 3·19 "		·386 = 4·19 "	
·485 = 1·52 "		·435 = 3·20 "		·385 = 4·20 "	
·484 = 1·62 "		·434 = 3·22 "		·384 = 4·22 "	
·483 = 1·62 "		·433 = 3·24 "		·383 = 4·24 "	
·482 = 1·73 "		·432 = 3·26 "		·382 = 4·28 "	
·481 = 1·78 "		·431 = 3·28 "		·381 = 4·28 "	
·480 = 1·83 "		·430 = 3·30 "		·380 = 4·30 "	
·479 = 1·88 "		·429 = 3·32 "		·379 = 4·32 "	
·478 = 1·89 "		·428 = 3·34 "		·378 = 4·34 "	
·477 = 1·98 "		·427 = 3·36 "		·377 = 4·36 "	
·476 = 2·00 "		·426 = 3·38 "		·376 = 4·38 "	
·475 = 2·04 "		·425 = 3·40 "		·375 = 4·40 "	
·474 = 2·08 "		·424 = 3·42 "		·374 = 4·42 "	
·473 = 2·13 "		·423 = 3·44 "		·373 = 4·44 "	
·472 = 2·16 "		·422 = 3·46 "		·372 = 4·46 "	
·471 = 2·20 "		·421 = 3·48 "		·371 = 4·46 "	
·470 = 2·24 "		·420 = 3·50 "		·370 = 4·50 "	
·469 = 2·28 "		·419 = 3·52 "		·369 = 4·52 "	
·468 = 2·31 "		·418 = 3·54 "		·368 = 4·54 "	
·467 = 2·34 "		·417 = 3·56 "		·367 = 4·56 "	
·466 = 2·37 "		·416 = 3·58 "		·366 = 4·58 "	
·465 = 2·40 "		·415 = 3·60 "		·365 = 4·60 "	
·464 = 2·42 "		·414 = 3·62 "		·364 = 4·62 "	
·463 = 2·46 "		·413 = 3·64 "		·363 = 4·64 "	
·462 = 2·49 "		·412 = 3·66 "		·362 = 4·66 "	
·461 = 2·52 "		·411 = 3·68 "		·361 = 4·68 "	
·460 = 2·55 "		·410 = 3·70 "		·360 = 4·70 "	
·459 = 2·58 "		·409 = 3·72 "		·359 = 4·72 "	
·458 = 2·61 "		·408 = 3·74 "		·358 = 4·74 "	
·457 = 2·64 "		·407 = 3·76 "		·357 = 4·76 "	
·456 = 2·67 "		·406 = 3·78 "		·356 = 4·78 "	
·455 = 2·70 "		·405 = 3·80 "		·355 = 4·80 "	
·454 = 2·73 "		·404 = 3·82 "		·354 = 4·82 "	
·453 = 2·76 "		·403 = 3·84 "		·353 = 4·84 "	
·452 = 2·79 "		·402 = 3·86 "		·352 = 4·86 "	
·451 = 2·82 "		·401 = 3·88 "		·351 = 4·88 "	
·450 = 2·85 "		·400 = 3·90 "		·350 = 4·90 "	

SCALE II.

LARGE LEAD CRUSHERS

("·500" diameter, and "·500" length).

Remaining Length.	Pressure in Tons.	Remaining Length.	Pressure in Tons.	Remaining Length.	Pressure in Tons.
·499		·449 = 8·37 tons		·399 = 10·79 tons	
·498		·448 = 8·44 "		·398 = 10·82 "	
·497		·447 = 8·51 "		·397 = 10·85 "	
·496		·446 = 8·58 "		·396 = 10·88 "	
·495		·445 = 8·65 "		·395 = 10·91 "	
·494		·444 = 8·72 "		·394 = 10·94 "	
·493		·443 = 8·79 "		·393 = 10·97 "	
·492		·442 = 8·86 "		·392 = 11·00 "	
·491		·441 = 8·93 "		·391 = 11·03 "	
·490		·440 = 9·00 "		·390 = 11·06 "	
·489		·439 = 9·05 "		·389 = 11·10 "	
·488		·438 = 9·10 "		·388 = 11·13 "	
·487		·437 = 9·15 "		·387 = 11·16 "	
·486		·436 = 9·20 "		·386 = 11·19 "	
·485		·435 = 9·25 "		·385 = 11·22 "	
·484		·434 = 9·30 "		·384 = 11·25 "	
·483		·433 = 9·35 "		·383 = 11·28 "	
·482 = 4·00 tons		·432 = 9·40 "		·382 = 11·31 "	
·481 = 4·20 "		·431 = 9·45 "		·381 = 11·34 "	
·480 = 4·40 "		·430 = 9·50 "		·380 = 11·37 "	
·479 = 4·60 "		·429 = 9·55 "		·379 = 11·40 "	
·478 = 4·80 "		·428 = 9·60 "		·378 = 11·43 "	
·477 = 5·00 "		·427 = 9·65 "		·377 = 11·49 "	
·476 = 5·17 "		·426 = 9·70 "		·376 = 11·49 "	
·475 = 5·34 "		·425 = 9·75 "		·375 = 11·52 "	
·474 = 5·50 "		·424 = 9·80 "		·374 = 11·55 "	
·473 = 5·67 "		·423 = 9·85 "		·373 = 11·58 "	
·472 = 5·84 "		·422 = 9·90 "		·372 = 11·61 "	
·471 = 6·00 "		·421 = 9·95 "		·371 = 11·64 "	
·470 = 6·15 "		·420 = 10·00 "		·370 = 11·67 "	
·469 = 6·30 "		·419 = 10·04 "		·369 = 11·70 "	
·468 = 6·44 "		·418 = 10·08 "		·368 = 11·74 "	
·467 = 6·57 "		·417 = 10·12 "		·367 = 11·77 "	
·466 = 6·70 "		·416 = 10·16 "		·366 = 11·80 "	
·465 = 6·82 "		·415 = 10·20 "		·365 = 11·84 "	
·464 = 6·94 "		·414 = 10·24 "		·364 = 11·87 "	
·463 = 7·06 "		·413 = 10·28 "		·363 = 11·90 "	
·462 = 7·17 "		·412 = 10·32 "		·362 = 11·94 "	
·461 = 7·28 "		·411 = 10·36 "		·361 = 11·97 "	
·460 = 7·39 "		·410 = 10·40 "		·360 = 12·00 "	
·459 = 7·50 "		·409 = 10·44 "			
·458 = 7·60 "		·408 = 10·48 "			
·457 = 7·70 "		·407 = 10·52 "			
·456 = 7·80 "		·406 = 10·56 "			
·455 = 7·90 "		·405 = 10·60 "			
·454 = 8·00 "		·404 = 10·64 "			
·453 = 8·06 "		·403 = 10·67 "			
·452 = 8·16 "		·402 = 10·70 "			
·451 = 8·23 "		·401 = 10·73 "			
·450 = 8·30 "		·400 = 10·76 "			

SCALE III.

COPPER CRUSHERS

("·250" diameter, and "·500" length).

Remaining Length.	Pressure in Tons.	Remaining Length.	Pressure in Tons.	Remaining Length.	Pressure in Tons.
·499		·449 = 17·20 tons		·399 = 25·25 tons	
·498		·448 = 17·40 "		·398 = 25·37 "	
·497		·447 = 17·60 "		·397 = 25·50 "	
·496		·446 = 17·80 "		·396 = 25·62 "	
·495		·445 = 18·00 "		·395 = 25·75 "	
·494		·444 = 18·20 "		·394 = 25·87 "	
·493		·443 = 18·40 "		·393 = 26·00 "	
·492		·442 = 18·60 "		·392 = 26·12 "	
·491		·441 = 18·80 "		·391 = 26·25 "	
·490		·440 = 19·00 "		·390 = 26·37 "	
·489		·439 = 19·17 "		·389 = 26·50 "	
·488		·438 = 19·33 "		·388 = 26·62 "	
·487		·437 = 19·50 "		·387 = 26·75 "	
·486		·436 = 19·67 "		·386 = 26·87 "	
·485		·435 = 19·83 "		·385 = 27·00 "	
·484		·434 = 20·00 "		·384 = 27·12 "	
·483		·433 = 20·17 "		·383 = 27·25 "	
·482		·432 = 20·33 "		·382 = 27·37 "	
·481		·431 = 20·50 "		·381 = 27·50 "	
·480		·430 = 20·67 "		·380 = 27·62 "	
·479		·429 = 20·83 "		·379 = 27·75 "	
·478		·428 = 21·00 "		·378 = 27·87 "	
·477		·427 = 21·17 "		·377 = 28·00 "	
·476		·426 = 21·33 "		·376 = 28·12 "	
·475		·425 = 21·50 "		·375 = 28·23 "	
·474		·424 = 21·67 "		·374 = 28·34 "	
·473 = 11·00 tons		·423 = 21·83 "		·373 = 28·45 "	
·472 = 11·33 "		·422 = 22·00 "		·372 = 28·56 "	
·471 = 11·67 "		·421 = 22·14 "		·371 = 28·67 "	
·470 = 12·00 "		·420 = 22·29 "		·370 = 28·78 "	
·469 = 12·33 "		·419 = 22·43 "		·369 = 28·86 "	
·468 = 12·67 "		·418 = 22·58 "		·368 = 29·00 "	
·467 = 13·00 "		·417 = 22·72 "		·367 = 29·12 "	
·466 = 13·25 "		·416 = 22·86 "		·366 = 29·23 "	
·465 = 13·50 "		·415 = 23·00 "		·365 = 29·34 "	
·464 = 13·75 "		·414 = 23·14 "		·364 = 29·45 "	
·463 = 14·00 "		·413 = 23·29 "		·363 = 29·56 "	
·462 = 14·25 "		·412 = 23·43 "		·362 = 29·67 "	
·461 = 14·50 "		·411 = 23·58 "		·361 = 29·78 "	
·460 = 14·75 "		·410 = 23·72 "		·360 = 29·89 "	
·459 = 15·00 "		·409 = 23·86 "		·359 = 30·00 "	
·458 = 15·25 "		·408 = 24·00 "			
·457 = 15·50 "		·407 = 24·14 "			
·456 = 15·75 "		·406 = 24·29 "			
·455 = 16·00 "		·405 = 24·43 "			
·454 = 16·20 "		·404 = 24·58 "			
·453 = 16·40 "		·403 = 24·72 "			
·452 = 16·60 "		·402 = 24·86 "			
·451 = 16·80 "		·401 = 25·00 "			
·450 = 17·00 "		·400 = 25·12 "			

process as nearly as we could do so. By means of hydraulic apparatus, specially made for the purpose, the weight was gradually lowered on to the lead or copper cylinder, and then lifted off again in a fraction of a second; and to this we attribute the satisfactory nature of the records that we have recently been able to publish.

It may be as well to mention that hardened lead varies, according as it contains more or less of alloy, and so a different scale would be required for each variation in hardness. We use ordinary unhardened lead (the specific gravity of which, as used for bullets in the Proof House, is 11·352). If harder lead be used, the crushing of the cylinder would be rather less than that stated in our scale. And the leads should not be measured until they are cold, as the metal developes heat by the pressure, and the lead gives higher readings as its temperature rises, and hardened metal varies more than soft lead. Mr. Griffith recently gave us the following records of differences in length of some hardened crusher-leads when the pressure remained equal:

Temperature of Lead.	Length. Inch.	Temperature of Lead.	Length. Inch.	Temperature of Lead.	Length. Inch.
30° Fahr.	·464	60° Fahr.	·4595	90° Fahr.	·455
40° ,, ...	·4635	70° ,, ...	·458	100° ,, ...	·4585
50° ,, ...	·461	80° ,, ...	·4565	110° ,, ...	·458

This may not make much difference to our ordinary climate, but if the leads are used in tropical or very cold climates, it may be necessary to make corrections, according to the temperature the leads cool down to; as with the same pressures, at temperatures varying from 40° to 90°, the readings would vary about 8 per cent., so that a record indicating 3 tons at the one temperature would be about 3¼ tons at the other.

We have, of late, adopted the practice of giving the pressures in tons and fractions of tons, instead of pounds, as formerly. It seemed to us much more easy to compare 2 tons, 2·25 tons, 2·75 tons, and so on, than to comprehend the difference between 4480, 5040, and 6160 pounds; while such fine distinctions as a few pounds more or less are practically useless, and are apt to lead people to imagine that there is an extremeness of accuracy in the records which cannot really exist in practice. And German readers can make a ready comparison with their own records by taking one ton as the equivalent for 150 atmospheres. In this way we have found some German records come very close to our own.

For the information of those of our readers who are less acquainted with the subject than Major Thiel, we may add that special crusher-gauges are required for different kinds of guns. Thus, for smooth-bores, we have crusher-gauges of 4, 8, 12, 16, and 20 gauge; but if, as occasionally happens, correspondents ask us to test cartridges of larger, smaller, or intermediate bores, that they think are possibly dangerous to the guns they possess, we are unable to comply with their requests; because to do so would necessitate the construction of special apparatus, which might probably cost us more than the value of their guns. In like manner we cannot generally undertake the testing of rifle cartridges; for not only is a different apparatus requisite for each difference in gauge, but also for every variation in the rifling. A 12-bore apparatus for shot guns will give no idea of the pressure in a 12-bore rifle; neither will a ·450 crusher-gauge, made for the Martini-Henry, give a correct representation of the pressure in a ·450 Express, or any other rifle that differs in rate of twist, shape of grooves, width of lands, or other conditions which add to or diminish the resistance to movement in the projectile, and consequently affect the development of force in the powder. In short, the conformation of the crusher-gauge apparatus requires to be internally the counterpart of the gun that it is intended to represent, but supplemented externally by such mechanism as is requisite for taking the records.—ED.]

NITRO POWDERS AND THEIR PRESSURES IN GUNBARRELS.

(*Fields*, 1894: Vol. 84, pp. 174, 220, 269, 294, 337, 339, 376, 415; as summarised for the *Rural Almanac* of 1895.)

MANY reports of trials of gunpowders have been published from time to time, but circumstances not unfrequently arise which serve to show that further investigation is desirable. Sometimes, for instance, a careless loader will put into a cartridge a much larger charge of nitro powder than its makers ever intended to be used; and a damaged gun, if no more serious accident, may be the result. And the effects of such an over-charge may possibly be more serious with some explosives than it would be with others. It is well, therefore, that sportsmen, if they think of making a change from the powder they have hitherto been in the habit of using in their guns, should have an opportunity of knowing whether the explosive they propose to adopt will be likely to necessitate greater care and attention on their own behalf, or on the part of the persons they employ to load their cartridges. It is also desirable to avoid, in ordinary or light 12-bores, the long cartridges made for use in heavy pigeon guns, as these cartridges contain considerably larger charges of powder and shot than are employed for ordinary game shooting.

In particulars published with respect to the pressure of powder-gases in the gunbarrel, the records that have ordinarily been given have had reference only to the amount of strain produced by charges in most general use—such as 3drs. of black powder in 12-bore guns, or the equivalent charges of nitro powders. It seemed desirable, however, to ascertain the probable effect of using, either by accident or design, some increased charges of powder—not only such as might be employed in ordinary cartridge cases, but also in those of greater length. We therefore carried out some experiments with charges increasing gradually from 3drs. to rather over 4drs., by adding 10grs. at each gradation with black powder; or 5grs. with such of the nitro-compounds which are about half the weight of black powder; and smaller amounts with those nitros which have a less quantity for their ordinary charges. The load of shot used throughout these experiments was 1⅛oz. of No. 6 for the 12-bore, 1oz. for the 16-bore, and ⅞oz. for the 20-bore. The wads were, first, a thin card on the powder, then a ⅜in. soft felt, next a grey cloth wad, followed by the shot, and another thin card over the shot; 2½in. cases were used for the first two charges, and 2¼in cases for the next two, except with the German powders (Walsrode and Von Förster), for which the long cartridges were not required, as the 2¼in. cases were large enough to hold the whole of the respective charges.

That the risks alluded to are not imaginary is obvious from the fact that guns have been burst, and persons have been more or less seriously injured, through inexperienced loaders making use of measures intended for black powder when they have been engaged in loading cartridges with nitro-compounds; such persons apparently acting under the mistaken supposition that any measure which will contain a suitable charge (say, 3drs.) for a certain gun (as an ordinary 12-bore), when filled with black powder, can likewise be used for the equivalent charge of all nitro powders. Such, however, is not the case, as will be seen by the following letter from New Zealand, with the editorial comment, published in the *Field* of Nov. 10, 1894:

SIR,—With much interest I have read your article on "Nitro Powders" in the *Field* of Aug. 4, which has just arrived here (New Zealand), and which records the pressure in the barrels made by the different powders.

Some four months ago I got some cartridges from a firm of ironmongers in Wellington, loaded with Walsrode, and the first one I fired burst the cartridge chamber of the left-hand barrel of my gun, and carried away with it all the muscle, &c., in the ball of my left thumb, also smashing the bone. The cartridges were loaded with 3drs., by measure, of Walsrode, and the pressure in the barrel must have been enormous. The gun was a good one, and I have fired hundreds of cartridges in her, including Schultze, E.C., S.S., and black powder, and never had any accident.

The firm I procured these cartridges from inform me that no directions as to loading were sent with the powder, consequently they loaded the cartridges just as they would have done with ordinary black. Several other guns were also burst; but I appear to be the only man injured, and that was owing to my habit of holding my left hand right under the cartridge chamber; and all the guns have burst there.

It is, I think, most culpable negligence to send powder out to this colony (or anywhere) without directions on the canister as to its strength and the quantity to put in cartridges.

H. S. HOOPER.

Waipukuran, Hawke's Bay, New Zealand, Oct. 1.

[We have frequently pointed out the danger which may result with some of the nitro powders if they are loaded by the ordinary "3dr. measure," as used for black powder. This measure will contain more than 50 grains of Walsrode, or nearly double the charge that ought to be used in a 12-bore, and greatly in excess of any charge used in our trials, in which only 37grs. produced a pressure of 5 tons. As to the powder being sent out in canisters without instructions as to loading, that is contrary to our experience. We have before us the printed "Instructions as to Loading" which are attached to an old canister in our possession; and, among them, it is said that "The Walsrode powder does not occupy so much space as any other nitro. . . . The proper charge for gauge 12 is 30grs. of Walsrode." Then follow particulars as to the best method of loading, with an illustration representing a cartridge loaded and wadded as recommended.—ED.]

The nitro powders vary considerably in strength and density, and there is great difference in the weight of equal measures of the various kinds of powders. Even black powders differ considerably, though not so widely as nitro powders. Some time ago we weighed samples of about a dozen black powders by different makers, and we found that a measure which would only contain 3drs. of one sample of black powder, would hold about 10 per cent. more (by weight) of another sample that was very similar in size of grain, but was denser and harder. Loaders of cartridges too often overlook the fact that the "dram" is, strictly speaking, a weight, and not a measure, as it is the 16th part of an avoirdupois ounce, or the 256th part of a pound of 7000 grains. But even the most ignorant of loaders would not be

likely to say that he had put an "ounce" of powder in a cartridge, if he had happened to charge it by means of a measure made to contain an ounce of shot; yet many persons say their cartridges are loaded with so many "drams" of nitro powder, although the charge contained therein may not weigh half as many drams as they state.

The extent to which nitro powders vary in weight, as compared with one another and with black powders, will be seen from the following figures, which show the respective number of grains of each contained in the same measure. This measure held 3drs. (or 82grs.) of Curtis & Harvey's No. 4 T.S. powder, slightly shaken down, but without pressing.

	Grains.		Grains.		Grains.
C. & H. No. 4	82	S.S.	39	Walsrode	52
Schultze	42	Amberite	40	Von Förster	28
E.C.	42	Cooppal	43		

The nitro powders, moreover, are apt to vary in weight, in different issues, to a greater extent than do black powder samples of the same brand; and some of the nitro powders are much more compressible than others. For instance, of the Von Förster powder (whereof 28grs. sufficed to fill the 3drs. measure when slightly shaken down), probably half as much again would go into the measure if it were much shaken or pressed. Again, the 3drs. measure, if filled with Walsrode powder, would contain about double the charge that ought to be used; and such a charge would produce greater strain in the barrel than would result from firing a double charge of black powder. It is not very surprising, therefore, that such disastrous effects should result as were mentioned in Mr. Hooper's letter from New Zealand; for the strain produced in the gun would much exceed that by which it had been tested in the official proof. In some 12-bore cartridges, one of which burst a gun in England in 1893, about 56grs. of Walsrode powder were found, and the pressure indicated in our crusher-gauge was between 8 and 9 tons, or about double the pressure given by the proof-charge for 12-bore guns. By a curious coincidence, these cartridges, like those in New Zealand, were supplied by a firm of ironmongers; and the person who loaded them was a youth of about fifteen.

What the pressures are by which guns are tested in the Proof Houses may be seen by the following figures, showing the results we obtained in six successive rounds with the charges and proof powder prescribed by law for 12-bore, 16-bore, and 20-bore guns. This proof powder, be it observed, does not give nearly so high a strain as would be given by a similar quantity of ordinary black gunpowder used for sporting purposes.

Proof Charges.	Tons per square inch.						Averages.
12-bore—3½drs. and 1⅛oz.....	4·02	4·04	4·10	4·16	4·18	4·20	= 4·12
16-bore—3½drs. and 1⅛oz.....	3·94	4·00	4·04	4·10	4·10	4·20	= 4·06
20-bore—3drs. and 1⅛oz	3·94	4·12	4·16	4·32	4·40	4·46	= 4·23

Here it will be seen that, although there was a difference between the first two proof-charges of a dram of powder and one-third of an ounce of shot, the strain in the 16-gauge was practically the same as in that of the larger bore; and with a further reduction of charge in the 20-bore, the strain in the barrel increased but slightly. It will be found, however, by the records hereafter given, that there was a much wider difference with some of the sporting powders. In certain instances the pressures considerably exceeded those of the proof-charges. Those records which equal or exceed the low pressures of the proof-charge (say four tons) we indicate below by printing them in blacker type. This amount of strain is about double the average of the pressures given by the whole of the powders tested in our experiments with the normal charge of 3drs. of black (or the equivalent charge of nitro-powders) with 1⅛oz. of No. 6 shot in the 12-bore gun. This average was just about two tons per square inch.

Our trials commenced in the 12-bore with the charge most generally adopted for that gauge, viz., 3drs. of powder and 1⅛oz. of shot; and the powder was gradually increased up to 4drs., which is the limit allowed to 12-bore pigeon guns. But pigeon guns are loaded with 1¼oz. of shot, whereas, in our tests, 1⅛oz. was retained throughout in this bore; and, consequently, the strain in the barrel with our trials may be considered to be somewhat lower than those likely to be produced by the full pigeon-charge. These experiments, rising by gradations from 3drs. to 4drs., were with black powder, of which two kinds were used, viz., Curtis and Harvey's No. 4 T.S. (treble strong), and the same firm's No. 2 T.S., which many sportsmen prefer to employ in the second barrel when they have a smokeless powder in the first.

With the nitro-compounds the charges varied considerably. Of the older kinds, such as Schultze and E.C., the charge used was about one-half the weight of black powder; and of the newer German varieties (Walsrode and Von Förster powders), the charge was one-third the weight of black, or as nearly so as was convenient. In the 16-bore, the shot used throughout was 1oz.: the powder charges commenced with 2½drs., and rose by somewhat similar gradations to 3½drs. With the 20-bore, the shot charge was ⅞oz., and the powder increased gradually from 2½drs. to 3drs. The proportions of the nitro charges were of a similar character, although not absolutely exact, as they were all weighed in even grains; but, where practicable, the exact proportions of 1, 1½, and 3 were followed. Thus, in the case of the 20-bore, where the German nitros had 22grs., English nitros had 33grs, and black powders 66grs; while the gradations of increase were respectively 2grs., 3grs, and 6grs. The comparative rates of increase in the three bores is shown in the following table:

Black Powders:	12-Bore.	16-Bore.	20-Bore.
Normal charge..	82grs., or 3drs. ...	74grs., or 2¾drs. ...	66grs., or 2½drs.
1st increase, to..	92grs., or 3½drs. ...	82grs., or 3drs. ...	72grs., or 2⅔drs.
2nd ,, ,,	102grs., or 3¾drs. ...	90grs., or 3⅓drs. ...	78grs., or 2⅞drs.
3rd ,, ,,	112grs., or 4drs. ...	98grs., or 3⅔drs. ...	84grs., or 3drs.

Here, the actual weight in "grains" is given, and the number of "drams" is also stated approximately. The whole of the charges were weighed, and it was not only desirable to keep the gradations exact, but also to adopt such rates of increase as would enable the number of grains to be divided, as nearly as possible, without resorting to fractions of a grain; so that about one-half the weight of black powder could be used with some of the nitro-compounds, and one-third the weight with others. Consequently the nitro charges adopted were as follows:

Schultze and others.	12-Bore.	16-Bore.	20-Bore.
Normal charge	42grs.	37grs.	33grs.
1st increase, to	47grs.	41grs.	36grs.
2nd ,, ,, ...	53grs.	45grs.	39grs.
3rd ,, ,, ...	57grs.	49grs.	42grs.
Walsrode and Von Förster:			
Normal charge	28grs.	24grs.	22grs.
1st increase, to	31grs.	27grs.	24grs.
2nd ,, ,, ...	34grs.	30grs.	26grs.
3rd ,, ,, ...	37grs.	33grs.	28grs.

The full details of the respective trials were stated in reports published in the *Fields* for Aug. 4, 18, and 25, 1894; but we here give only a concise summary of the results, showing the average pressures exhibited in the six rounds fired from each of the three bores. It will be observed, in the preceding tables of powder charges, that the normal charge for the 12-bore (*i.e.*, 3drs. of black powder, or its nitro equivalent) is nearly identical in quantity with the "first increase" in the 16-bore, or the "third increase" in the 20-bore. Accordingly, in the next table, we indicate these charges by placing an asterisk (*) before them, so that the reader may be able to see at a glance how much more strain is produced in the barrel when the same charge of powder is used in a smaller bore.

BLACK POWDERS.	Pressures in Tons per square inch. 12-Bore.	16-Bore.	20-Bore.
C. & H. No. 4, normal charge	*2·23	2·44	2·90
,, ,, 1st increase	2·80	*2·89	3·04
,, ,, 2nd ,, ...	3·12	3·25	3·27
,, ,, 3rd ,, ...	3·49	3·72	*3·63
	12-Bore.	16-Bore.	20-Bore.
C. & H. No. 2, normal charge	*3·33	3·71	3·70
,, ,, 1st increase	3·80	*3·74	4·17
,, ,, 2nd ,, ...	4·23	4·10	4·07
,, ,, 3rd ,, ...	4·63	4·85	*4·29

It is curious to see how differently the same powders occasionally behave when there is an alteration in the charge in the same barrel. With No. 2 black, as shown above, the first increase in the 20-bore raised the strain considerably; but with the second increase of the powder the strain slightly diminished; and, although with the third increase of powder there was an addition to the pressure, it was considerably less than was exhibited in the larger bores. It must be remembered, too, that these records were not the results merely of single rounds, but are averages of six successive rounds. Possibly, however, these differences may be due to atmospheric differences, the trials not taking place on the same day.

With the nitro-compounds, however, the pressures were always highest in the 20-bore. A few of them were very high—far exceeding the proof charge; but others were below the pressures given by No. 4 black powder, stated above, and considerably below No. 2, as will be seen by the following figures:

NITRO-COMPOUNDS.	12-Bore.	16-Bore.	20-Bore.
Schultze, normal charge	*1·65	2·20	2·49
,, 1st increase	2·29	*2·78	3·38
,, 2nd ,, ...	2·30	3·02	3·23
,, 3rd ,, ...	2·46	3·16	*3·31

NITRO-COMPOUNDS.	12-Bore.	16-Bore.	20-Bore.
E.G., normal charge	*1·48	2·17	2·62
„ 1st increase	2·13	*2·53	3·16
„ 2nd „	2·93	3·41	3·46
„ 3rd „	3·03	3·81	*3·82
	12-Bore.	16-Bore.	20-Bore.
S.S., normal charge	*3·25	3·13	3·47
„ 1st increase	3·55	*3·97	4·62
„ 2nd „	3·77	4·22	5·00
„ 3rd „	4·07	4·93	*6·05
	12-Bore.	16-Bore.	20-Bore.
Amberite, normal charge	*2·06	2·78	3·63
„ 1st increase	2·02	*3·45	3·53
„ 2nd „	2·84	3·50	4·51
„ 3rd „	3·01	3·70	4·06
	12-Bore.	16-Bore.	20-Bore.
Cooppal, normal charge	*1·68	2·64	2·92
„ 1st increase	2·18	*4·03	4·71
„ 2nd „	2·81	4·74	5·11
„ 3rd „	3·66	5·27	*7·53
	12-Bore.	16-Bore.	20-Bore.
Walsrode, normal charge	*2·12	2·17	2·53
„ 1st increase	3·21	*2·81	3·71
„ 2nd „	3·71	3·33	4·28
„ 3rd „	4·60	4·28	*5·17

It is needless for us to attempt to increase the eloquence of the above black-looking figures; but we may conclude by adding that with a further diminution in the size of bore, there probably would be a still greater increase of strain in the barrel.

With all the above powders, both black and nitro (except Walsrode), the cartridge cases were alike, viz., Eley's best quality, green. Some cases for Walsrode were also by the same makers, but were specially made for this powder, and have a base of different shape from that in Eley's ordinary cases. The Walsrode powder was likewise tested in some Belgian cases, specially made for this explosive by Bachmann, of Brussels. With these cases the pressures were much below those given in the English cases, as will be seen by comparing the following records with those given above:

	12-Bore.	16-Bore.	20-Bore.
Walsrode (in Bachmann cases), normal charge	*1·88	1·35	2·24
„ 1st increase	1·78	*1·76	2·76
„ 2nd „	2·04	2·55	2·85
„ 3rd „	2·85	3·10	*3·20

These Belgian cases likewise reduced the strain with some of the other powders that gave high pressures; for instance, the normal charge of S.S., which gave an average strain of 3·25 tons in the 12-bore, as shown in the previous table, averaged only 1·81 tons in the Bachmann cases; but we had not a sufficient supply of them to extend the experiments.

With the Von Förster powder, German cartridge cases, specially supplied by Herr Von Förster, were used, and the pressures recorded were surprisingly low. In the 12-bore, the normal charge was tried, and the three subsequent increases, but the pressures with each were under 1 ton; and the same occurred in the 16-bore. In the 20-bore, the pressures with the normal charge and the first increase were under 1 ton; with the second increase, the pressure rose to 1·92 tons; and with the third increase it was 3·20 tons.

These low pressures, with the foreign cartridge cases, were attended with some reduction of speed in the shot, as compared with the velocities recorded by the same charges in the English cases; but the difference of velocities was not at all commensurate with the difference of strain in the barrel, as will be seen by the following comparative table of velocities and pressures, as recorded with the normal charge of each. The velocities here given are the averages of six rounds, as taken by chronograph, in a range of 5 yards; consequently they are several hundred feet higher than those taken in a range of 40 yards, and approximate closely to the speed with which the shot leaves the muzzle of the gun.

	12-Bore.		16-Bore.		20-Bore.	
Black Powders:	Velocity. Ft. sec.	Strain. Tons.	Velocity. Ft. sec.	Strain. Tons.	Velocity. Ft. sec.	Strain. Tons.
C. & H. No. 4 T.S.	1197	2·23	1223	2·44	1135	2·90
C. & H. No. 2 T.S.	1251	3·33	1296	3·71	1224	3·70
Nitro-Compounds:						
Schultze	1205	1·65	1216	2·20	1043	2·49
E.C.	1193	1·63	1207	2·17	1084	2·81
S.S.	1188	3·25	1169	3·13	1197	3·47
Amberite	1090	2·03	1211	2·78	1047	3·33
Cooppal	1232	1·68	1240	2·64	1148	3·22
Walsrode (Eley)	1177	3·12	1182	2·17	1098	3·53
Ditto (Bachmann)	1019	1·49	984	1·22	951	1·76
Von Förster	1114	1·00*	1045	1·00*	994	1·00*

* All under one ton.

The above velocities, and the amount of strain in the barrel, were all taken with practically equal charges, viz., the normal charge described above; and it will be seen that the muzzle velocities varied considerably in the different gauges; and there was a great reduction of speed with some of the nitros, notwithstanding the high pressure in the barrel. Subsequently we tried some experiments with the same explosives at a forty yards range, and varied the charges of powder so as to produce as nearly as possible a uniform velocity. The records of these experiments are given in the next article.

STANDARD RECORDS WITH 12, 16, AND 20-BORE GUNS.

(*Fields*, 1894; vol. 84, pp. 488, 556, 748.)

We have endeavoured to convey to our readers, in a previous article, some knowledge of the peculiarities of behaviour of different varieties of sporting gunpowders, when tested under similar conditions. The results of these tests went to show that nearly every nitro powder has special characteristics of its own. Some of them did not raise the pressure inordinately with the increased charges; while with others the amount of strain was excessive, more especially in the smaller bores. We need hardly say that our employment of these large charges was not for the purpose of suggesting their adoption, but for the very opposite. We think the use of excessive charges is a mistake, even when the powders are of a mild character; and with some explosives such excesses may be disastrous.

Our present purpose is of a different nature; but for this a "datum line" is requisite. One frequently hears people say, with respect to their favourite powder, that "it sends the shot up to the game much quicker than any other powder." On such matters, the records of the chronograph are better evidence than the vague impressions produced by firing off a gun. The mind is apt to be influenced by the sensations which result from the pulling of the trigger—the difference of "kick," the greater or less amount of smoke, and so on; but a chronograph has no eyes for smoke, and a machine-rest, for registering recoil, has no nerves, and does not suffer from "gun-headache." Each performs its duty with most provoking regularity—especially when the teachings are in conflict with pre-existing impressions, based wholly on surmise.

Mr. John Rigby was the first, as far as we are aware, to call attention to the time taken, with charges in general use, for the shot to traverse the distance of 40 yards; and he said, in a letter to the *Field*, about fifteen years ago, that the time for a good 12-bore, with 3½drs. of powder and 1⅛oz. of No. 6 shot, was about one-seventh of a second, or at the rate of 840ft. per second. With the improvements in cartridges and wads that have been effected since that day, similar results may now be produced by rather smaller quantities of powder; and in our present experiments we have taken a velocity (850ft.), which closely resembles Mr. Rigby's, as the "standard" of comparison between the various explosives.

These velocities, it should be understood, do not represent the actual speed with which the shot leaves the muzzle of the gun, nor that with which the shot strikes the bird; but they indicate the average speed for the whole distance, and, consequently, if several kinds of powder give the same mean velocity for 40 yards, the shot would take equal time to traverse the space between gun and target. Hence it follows that one charge would not be any quicker than the rest in "getting up to game" at 40 yards from the gun.

The mean velocities for 5 yards, as published in the previous article, give a much closer representation of the muzzle velocity of the respective charges; and they average about 1200ft. per second; while the actual velocity at the end of forty yards would probably be about 600 f.s. with the fastest pellets of the charge, and rather less with those pellets which had undergone most retardation in passing through the atmosphere.

In order to obtain the datum line above alluded to (850 f.s.), we made some experiments with the respective powders, for the purpose of ascertaining what charges would give this mean velocity; and we increased or decreased the quantity of powder (the shot-charge remaining unaltered) until we obtained an average closely approximating to the standard of 850 f.s.

With 3drs. of C. & H. No. 4 that standard was slightly surpassed; and in order to obtain a similar result with No. 2 powder, we had to reduce the charge to 70grs., or little more than 2½drs.; yet this greatly-reduced charge gave identically the same average for the six rounds as 82grs. of No. 4. Three records (viz., for velocity, recoil, and pattern) were taken from the same round in each instance; but it will be seen that there are some differences of recoil and pattern even when the velocities are identical; and for such differences we think that variations of strength in the caps must be mainly

responsible. The average pressures, in tons per square inch, are stated at the end of the other records; these could not be taken simultaneously with the other three. The gun used was a 7lb. 12-bore, the choked barrel only being employed. We prefer to use the chokebore, as the fluctuations in pattern are more readily observed.

VELOCITY, RECOIL, and PATTERN (taken simultaneously).

							Averages.	Strain.
No. 4 BLACK: (82grs. and 1½oz.)	Velocity	839	843	854	858	859	860=852ft.sec.	2·37 tons.
	Recoil ...	*35·2*	*34·7*	*34·6*	*35·0*	*34·5*	*34·5=34·8ft.lb.*	
	Pattern.	120	171	187	163	166	174=164 patt.	
No. 2 BLACK: 70grs., and 1½oz.)	Velocity	848	851	851	853	854	857=852ft.sec.	3·03 tons.
	Recoil ...	*31·2*	*30·8*	*31·5*	*31·0*	*31·1*	*31·0=31·1ft.lb.*	
	Pattern.	180	188	160	176	165	175=174 patt.	

A difference of only 9 f.s. in velocity, in six successive rounds, is an excellent record; and a reduction of more than 10 per cent. of recoil, without any diminution of velocity, tells much in favour of 70grs. of No. 2, as compared with 82grs. of No. 4. The pattern, too, is a little larger than with No. 4; but the strain in the barrel still remained rather high, though reduced below what it had been with the full charge.

With the nitro powders, as will be found in the following particulars, we had to make various changes from the normal loads, in order to reach the datum-level of 850 f.s. velocity. The nitro powders were not all of exactly the same issue as those tried in the former experiments, as we were asked to test more recent issues of several of them. We likewise received some new Eley 12-bore cartridge cases, especially made for Walsrode powder. They have a conical or cupped base, similar to that in some foreign cartridge cases, and we believe some change is also made in the caps. With this new case the Walsrode powder gives a much lower strain than it did in previous English cases, though the pressure is not yet so low as in Belgian cases.

The following records include the results shown by these new issues; and it will be observed that in some instances the charges are higher, and in others a little lower, than those employed in the previous experiments. Such alterations have been made in order to attain the datum-level before mentioned, as regards velocity. But if the charges are thus altered, the pressures likewise may be changed; so we thought it best to test all again for strain in the barrel. The records of each powder are not printed in the order in which the rounds were fired, but in accordance with the amount of velocity registered; and it will be observed that the highest velocity is not necessarily accompanied by the greatest recoil or the largest pattern, although they occasionally go together. The results, with the respective nitro-compounds, in the 12-bore gun, were as here stated:

VELOCITY, RECOIL, and PATTERN (taken simultaneously).

							Averages.	Strain.
SCHULTZE: (42grs. and 1½oz.)	Velocity	839	840	850	855	861	862=851ft.sec.	1·93 tons.
	Recoil ...	*26·8*	*26·9*	*27·0*	*28·0*	*28·7*	*28·3=27·6ft.lb.*	
	Pattern.	182	213	215	190	197	221=203 patt.	
E.C.: (46grs. and 1½oz.)	Velocity	820	842	846	857	857	858=847ft.sec.	1·54 tons.
	Recoil ...	*26·6*	*28·0*	*28·5*	*28·3*	*29·0*	*29·5=28·3ft.lb.*	
	Pattern.	202	118	180	212	219	191=187 patt.	
S.S.: (41grs. and 1½oz.)	Velocity	788	851	853	854	855	855=843ft.sec.	2·33 tons.
	Recoil ...	*23·6*	*28·0*	*27·8*	*27·9*	*27·0*	*28·1=27·1ft.lb.*	
	Pattern.	148	179	210	200	191	189=186 patt.	
AMBERITE: (40grs. and 1½oz.)	Velocity	817	839	850	857	858	890=852ft.sec.	1·92 tons.
	Recoil ...	*24·2*	*26·2*	*26·0*	*27·5*	*26·8*	*31·0=27·0ft.lb.*	
	Pattern.	214	174	180	183	206	195=192 patt.	
COOPPAL: (45grs. and 1½oz.)	Velocity	798	847	851	851	868	868=847ft.sec.	1·58 tons.
	Recoil ...	*23·0*	*26·6*	*27·7*	*28·0*	*28·0*	*30·0=27·3ft.lb.*	
	Pattern.	186	184	184	152	189	160=178 patt.	
WALSRODE: Eley case (33grs. and 1½oz.)	Velocity	843	851	853	855	856	861=853ft.sec.	1·98 tons.
	Recoil ...	*25·5*	*25·5*	*25·6*	*26·4*	*26·5*	*25·6=25·0ft.lb.*	
	Pattern	201	211	210	189	178	195=197 patt.	
Ditto: Bachmann (36grs. and 1½oz.)	Velocity	842	849	850	853	854	857=851ft.sec.	1·10 tons.
	Recoil ...	*25·5*	*26·7*	*26·9*	*28·0*	*27·0*	*28·0=27·0ft.lb.*	
	Pattern	188	180	196	200	190	179=189 patt.	
VON FÖRSTER (33grs. and 1½oz.)	Velocity	807	820	843	846	858	847=844ft.sec.	1·15 tons.
	Recoil ...	*25·1*	*25·0*	*25·3*	*26·8*	*27·0*	*29·0=26·4ft.lb.*	
	Pattern	116	170	208	211	191	187=180 patt.	

With the old special Eley case, and 28grs. of Walsrode, the strain in the barrel amounted to 3·12 tons; with the new Eley case, and 33grs. of the same powder, the strain was reduced to 1·98 tons; but the pressure in the Bachmann case, with the charge raised to 36grs., was still lower.

THE 16-BORE.

In obtaining records with the 16-bore gun, we followed a very similar course to that adopted for the 12-bore. We took as the standard of velocity 850 feet per second, in a range of 40 yards; and with the 12-bore the actual average (with six rounds each of the whole of the powders) amounted to 849 f.s. The average pattern made by the 12-bore, with 1¼oz. of No. 6 shot, was rather over 180 pellets in the 30in. circle at 40 yards; and, the 16-bore charge being one-ninth less, the corresponding standard of comparison would be 160 for the smaller bore; but the 16-bore was not so fully choked as the 12-bore, and the average pattern may be taken as about 150. The average recoil, with the whole of the 12-bore charges, was almost exactly 28 ft.lb.; and this, with a 7lb. gun and 1¼oz. shot, is equivalent to a recoil velocity of 16 ft.sec. With a 16-bore gun and 1oz. of shot, the corresponding weight of the weapon would be 6¼lb.; and this was the weight of the gun here used. With a gun of this weight and 16 f.s. recoil velocity the energy of recoil would be equal to 25 ft.lb. The average pressure per square inch, with the whole of the powder-charges used in the 12-bore, was just about 2 tons; and this may be taken as a standard in comparing the strain in the 16-bore barrel.

As was the case with the 12-bore experiments, we commenced proceedings by ascertaining how the black powders behaved. Generally speaking, we expect these to be less affected by change of bore than is the case with the nitro-compound explosives. Curiously enough, however, we found that, whereas No. 4 black, with 77grs. of powder and 1oz. of lead, gave in the 16-bore the same amount of velocity as 82grs. and 1¼oz. in the 12-bore (or, in other words, there was a reduction of rather more than one-sixth of a dram of powder), yet no similar reduction could be made with No. 2 black. To produce the standard velocity, it was requisite to employ 70grs. of No. 2—exactly the same charge as was used to impart equal velocity to 1¼oz. of shot in the 12-bore. This will be seen by comparing the following figures with those published above:

VELOCITY, RECOIL, and PATTERN (taken simultaneously).

							Averages.	Strain.
No. 4 BLACK: (77grs. and 1oz.)	Velocity	845	849	850	851	851	853=850ft.sec.	2·90 tons.
	Recoil ...	*30·0*	*30.8*	*30·0*	*31·0*	*31·1*	*31·5=30·7ft.lb.*	
	Pattern.	130	141	135	150	145	138=140 patt.	
No. 2 BLACK: (70grs. and 1oz.)	Velocity	845	849	851	853	854	854=851ft.sec.	3·49 tons.
	Recoil ...	*30·5*	*29·9*	*29·8*	*30·0*	*30·0*	*30·0=30·0ft.lb.*	
	Pattern.	130	141	120	138	144	133=134 patt.	

Nevertheless, with the (comparatively) larger charge of No. 2, the strain in the 16-bore barrel did not increase so much as it did with the reduced charge of No. 4. With the latter, the pressure rose 24 per cent., as compared with the 12-bore; but with No. 2 it increased only 15 per cent. Now we proceed with the velocities, &c., of the nitro powders.

VELOCITY, RECOIL, and PATTERN (taken simultaneously).

							Averages.	Strain.
SCHULTZE: (38grs. and 1oz.)	Velocity	846	847	848	849	850	867=851ft.sec.	2·10 tons.
	Recoil ...	*25·1*	*25·0*	*25·3*	*25·5*	*26·0*	*27·0=25·7ft.lb.*	
	Pattern.	158	138	147	178	173	141=156 patt.	
E.C.: (40grs. and 1oz.)	Velocity	828	845	849	850	851	890=840ft.sec.	2·01 tons.
	Recoil ...	*23·6*	*24·9*	*25·0*	*24·8*	*25·2*	*25·0=24·8ft.lb.*	
	Pattern.	132	154	149	147	167	155=151 patt.	
S.S.: (38grs. and 1oz.)	Velocity	830	832	844	851	865	866=848ft.sec.	3·18 tons.
	Recoil ...	*25·0*	*25·5*	*25·8*	*26·3*	*27·0*	*27·0=26·1ft.lb.*	
	Pattern.	161	168	150	155	143	148=154 patt,	
AMBERITE: (37grs. and 1oz.)	Velocity	845	848	850	851	865	871=855ft.sec.	2·73 tons.
	Recoil ...	*24·1*	*24·0*	*25·0*	*25·8*	*26·2*	*27·0=25·4ft.lb.*	
	Pattern.	157	176	150	147	133	131=149 patt.	
COOPPAL: (40grs. and 1oz.)	Velocity	847	849	849	850	850	872=853ft.sec.	2·25 tons.
	Recoil ...	*25·6*	*25·8*	*26·0*	*26·0*	*26·1*	*28·0=26·3ft.lb.*	
	Pattern.	158	137	165	154	141	130=148 patt.	

WALSRODE (Eley cases)—None obtainable.

WALSRODE: Bachmann cases (34grs. and 1oz.)	Velocity	843	849	850	851	854	863=852ft.sec.	2·11 tons.
	Recoil ...	*25·0*	*25·0*	*25·2*	*25·1*	*25·6*	*26·0=25·3ft.lb.*	
	Pattern.	158	139	154	150	143	137=147 patt.	
VON FÖRSTER (30grs. and 1oz.)	Velocity	829	840	845	850	853	868=848ft.sec.	1·18 tons.
	Recoil ...	*23·0*	*22·6*	*23·4*	*24·0*	*23·3*	*24·5=23·5ft.lb.*	
	Pattern.	140	144	150	156	143	171=151 patt.	

THE 20-BORE.

One remarkable peculiarity in connection with the 20-bore is that, notwithstanding the reduction of the shot-charge, a much larger proportion of powder is necessary, in order to give as high a velocity

as is exhibited in the 12-bore with the ordinary charge of 3drs. and 1⅛oz.

In the experiments with the 12-bore, we took as the standard of velocity 850 ft.sec., that being the rate of speed given by 3drs. of Curtis and Harvey's No. 4 black powder; and the charges of all the other powders were so arranged as to produce a similar velocity, the quantities of powder being varied, in experimental tests, until they gave as nearly as possible identical results. In the 16-bore, the same standard was also taken. Now we give details of the trials of the 20-bore; and these will show how much more powder (comparatively speaking) was requisite to impart, in the small-bore guns, as high an amount of velocity as was given by the 12-bore.

The following table will show what were the quantities of powder found necessary to give about 850 f.s. velocity in the three bores, the shot being, as before stated, 1⅛oz., 1oz., and ⅞oz. respectively:

	12-bore.	16-bore.	20-bore.
No. 4 Black	82 grs.	77 grs.	78 grs.
No. 2 „	70 „	70 „	66 „
Schultze	43 „	38 „	42 „
E.C.	46 „	40 „	43 „
S.S.	41 „	38 „	40 „
Amberite	40 „	37 „	35 „
Cooppal	45 „	40 „	44 „
Walsrode (Eley case)	33 „	— „	— „
Ditto (Bachmann)	36 „	34 „	33 „
Von Förster (German)	33 „	30 „	35 „

In several instances, it will be observed, the quantity of powder required in the 20-bore (to give an equal velocity) was much the same as was used in the 12-bore with ½oz. more shot; and in the last instance the 20-bore charge was larger than that used for the 12-bore. Hence with such charges, in the narrow gauge, the strain in the barrel went up considerably. The recoil also is high for a 20-bore, as will be seen by the next table. The gun used was a full choke, weighing 5¾lb., and it gave just about the same pattern as the 16-bore with ½oz. more shot, viz., an average of about 150 pellets in the 30in. circle. With a cylinder gun the same velocity would not have been obtained even with these charges, as much speed is lost when the shot is scattered.

VELOCITY, RECOIL, and PATTERN (taken simultaneously).

							Averages.	Strain.
No. 4 BLACK: (78grs. and ⅞oz.)	Velocity	844	844	849	860	866	871=856ft.sec.	3·09 tons.
	Recoil ...	*30·8*	*31·0*	*31·0*	*31·8*	*31·0*	*31·0=31·3ft.lb.*	
	Pattern.	163	100	177	115	106	132=131 patt.	
No. 2 BLACK: (66grs. and ⅞oz.)	Velocity	840	845	850	855	857	863=852ft.sec.	3·59 tons.
	Recoil ...	*28·0*	*29·0*	*28·8*	*28·9*	*28·7*	*29·5=28·8ft.lb.*	
	Pattern.	101	140	154	126	147	161=138 patt.	
SCHULTZE: (43grs. and ⅞oz.)	Velocity	838	848	849	854	870	872=854ft.sec.	2·45 tons.
	Recoil ...	*22·0*	*24·4*	*24·7*	*24·2*	*26·0*	*25·0=24.5ft.lb.*	
	Pattern.	175	136	172	169	166	147=161 patt.	
E.C.: (43grs. and ⅞oz.)	Velocity	831	836	842	862	867	869=851ft.sec.	2·70 tons.
	Recoil ...	*25·0*	*25·5*	*24·4*	*24·2*	*24·5*	*24·8=24·7ft.lb.*	
	Pattern.	148	128	158	144	160	155=149 patt.	
S.S.: (40grs. and ⅞oz.)	Velocity	834	845	850	851	855	872=851ft.sec.	4·19 tons.
	Recoil ...	*24·8*	*25·0*	*25·3*	*25·1*	*25·5*	*27·7=25·6ft.lb.*	
	Pattern.	140	151	153	141	128	159=145 patt.	
AMBERITE: (35grs. and ⅞oz.)	Velocity	840	851	853	855	867	867=856ft.sec.	2·87 tons.
	Recoil ...	*23·8*	*24·5*	*24·8*	*25·5*	*23·7*	*24·0=24·4ft.lb.*	
	Pattern.	170	160	166	178	158	147=162 patt.	
COOPPAL: (44grs. and ⅞oz.)	Velocity	821	839	850	851	855	860=844ft.sec.	3·57 tons.
	Recoil ...	*26·3*	*25·7*	*25·8*	*26·0*	*26·0*	*26·0=26·0ft.lb.*	
	Pattern.	150	153	149	130	126	138=141 patt.	
WALSRODE (Eley cases)—None obtainable.								
WALSRODE (Bachmann cases), 33grs. and ⅞oz.	Velocity	850	851	851	853	854	855=852ft.sec.	3·39 tons.
	Recoil ...	*23·5*	*23·7*	*24·0*	*24·4*	*23·8*	*23·3=23·8ft.lb.*	
	Pattern.	156	147	160	151	153	153=154 patt.	
VON FÖRSTER (German cases), 35grs. and ⅞oz.	Velocity	773	851	854	854	856	857=841ft.sec.	2·54 tons.
	Recoil ...	*20·7*	*24·1*	*25·0*	*26·1*	*26·9*	*24·3=24·5ft.lb.*	
	Pattern.	148	130	143	147	141	135=141 patt.	

GENERAL SUMMARY OF THE THREE BORES.

In the next comparative table are summarised the records of velocity and pattern, recoil and strain in the barrel. The velocity remains pretty nearly constant in the three bores; the pattern diminishes with the reduction of the shot-charge, though there is not much difference between the 16-bore and 20-bore, for the reason previously stated. Considering that the shot-charge in the 16-bore is diminished by 11 per cent., and that of the 20-bore by 22 per cent., the recoil with these bores stands comparatively high; and with some powders the strain is nearly doubled. All the cartridge cases used were of Messrs. Eley's ordinary make, unless otherwise stated. We have included in this summary some new cases made by Messrs. Joyce.

	Velocity.	Pattern.	Recoil.	Strain.
No. 4 BLACK:				
12-bore, 82grs.: 1⅛oz.	852 ft.sec.	164	34·8 ft.lb.	2·37 tons.
16 „ 77grs.: 1oz.	850 „	140	30·7 „	2·90 „
20 „ 78grs.: ⅞oz.	856 „	131	31·3 „	3·09 „
No. 2 BLACK:				
12-bore, 70grs.: 1⅛oz.	852 ft.sec.	174	31·1 ft.lb.	3·03 tons.
16 „ 70grs.: 1oz.	851 „	134	30·0 „	3·49 „
20 „ 66grs.: ⅞oz.	852 „	138	28·8 „	3·59 „
SCHULTZE:				
12-bore, 43grs.: 1⅛oz.	851 ft.sec.	208	27·6 ft.lb.	1·93 tons.
16 „ 38grs.: 1oz.	851 „	156	25·7 „	2·10 „
20 „ 42grs.: ⅞oz.	854 „	161	24·5 „	2·45 „
E.C. (with Eley's cases):				
12-bore, 46grs.: 1⅛oz.	847 ft.sec.	187	28·3 ft.lb.	1·54 tons.
16 „ 40grs.: 1oz.	849 „	151	24·8 „	2·01 „
20 „ 43grs.: ⅞oz.	851 „	149	24·7 „	2·70 „
E.C. (with Joyce's cases):				
12-bore, 48grs.: 1⅛oz.	855 ft.sec.	188	29·2 ft.lb.	1·21 tons.
S.S. (with Eley's cases):				
12-bore, 41grs.: 1⅛oz.	843 ft.sec.	196	27·1 ft.lb.	2·33 tons.
16 „ 38grs.: 1oz.	848 „	154	26·1 „	3·18 tons.
20 „ 40grs.: ⅞oz.	851 „	145	25·6 „	4·19 tons.
S.S. (with Joyce's cases):				
12-bore, 42grs.: 1⅛oz.	854 ft.sec.	195	28·1 ft.lb.	2·31 tons.
AMBERITE (with Eley's cases):				
12-bore, 40grs.: 1⅛oz.	852 ft.sec.	192	27·0 ft.lb.	1·92 tons.
16 „ 37grs.: 1oz.	855 „	149	25·4 „	2·73 tons.
20 „ 35grs.: ⅞oz.	856 „	162	24·4 „	2·87 tons.
AMBERITE (with Joyce's cases):				
12-bore, 44grs.: 1⅛oz.	856 ft.sec.	190	29·4 ft.lb.	1·29 tons.
COOPPAL:				
12-bore, 45grs.: 1⅛oz.	847 ft.sec.	178	27·2 ft.lb.	1·58 tons.
16 „ 40grs.: 1oz.	853 „	148	26·3 „	2·25 tons.
20 „ 44grs.: ⅞oz.	844 „	141	26·0 „	3·57 tons.
WALSRODE (with Eley's special cases, No. 1):				
12-bore, 28grs.: 1⅛oz.	—	—	—	3·12 tons.
16 „ 24grs.: 1oz.	—	—	—	2·17 „
20 „ 22grs.: ⅞oz.	—	—	—	3·56 „
***WALSRODE (with Eley's special cases, No. 2):**				
12-bore, 33grs.: 1⅛oz.	853 ft.sec.	197	25·9 ft.lb.	1·93 tons.
WALSRODE (with Joyce's cases):				
12-bore, 32grs.: 1⅛oz.	849 ft.sec.	205	26·1 ft.lb.	2·49 tons.
WALSRODE (with Bachmann cases):				
12-bore, 36grs.: 1⅛oz.	851 ft.sec.	189	27·0 ft.lb.	1·10 tons.
16 „ 34grs.: 1oz.	852 „	147	25·3 „	2·11 „
20 „ 33grs.: ⅞oz.	852 „	154	23·8 „	3·39 „
VON FÖRSTER:				
12-bore, 33grs.: 1⅛oz.	844 ft.sec.	180	26·4 ft.lb.	1·15 tons.
16 „ 30grs.: 1oz.	848 „	151	23·5 „	1·18 „
20 „ 35grs.: ⅞oz.	841 „	141	24·5 „	2·54 „

* We regret that, owing to our inability to obtain a supply of Eley's special No. 2 for 16 and 20 bores, we have not been able to complete the records.

P.—T.

THE PRESSURE OF POWDER GASES IN GUNBARRELS.

(*Field*, March 31, 1888; Vol. 71, p. 440.)

OF THE MANY puzzling problems connected with guns, none have elicited more divergent experimental results than those relating to the pressure exerted in the barrel by sporting charges of powder and shot. Such divergences naturally produce a confusing effect on the mind of the reader; and we therefore propose, by a comparison of the work of different experimenters, to try and ascertain whether a certain amount of harmony may not be found among statements that seem to be greatly in conflict. And if, in so doing, we venture to point out what appears to us to be erroneous, we shall not do so in anything like a carping spirit; for where men are honestly working to arrive at right conclusions, and incurring much trouble and expense in their endeavours to obtain satisfactory results, it ill becomes spectators to indulge in mere fault-finding. Captious criticism cannot be of advantage to anyone; whereas earnest efforts to reconcile apparent antagonisms may not improbably result in the discovery of where the truth really lies.

The earliest investigations of this kind that we can call to mind were made by Messrs. John Hall and Sons, the well-known powder manufacturers, who, some ten years or more ago had a crusher-gauge constructed, which took one pressure at the breech by means of a copper disc; and by experiments with this apparatus it was estimated that the force exerted by 3drs. of No. 5 powder amounted to about 2400lb. per square inch, and that with No. 2 powder it rose to about 3600lb. In 1878, at the time of the *Field* Gun Trial with Black and Schultze powders, Mr Walsh carried out a number of experiments with a strong spring balance, acted on by levers, and he found that, by dropping a weight of seven or eight pounds a distance of a foot, the records upon the machine were very similar to those produced by firing 3drs. of powder with 1⅛oz. of shot—the actual weight required varying, of course, with the description of powder used. And even when a copper disc, instead of the spiral spring, received the blow of the falling weight, it was compressed to an extent closely corresponding with the effect produced by firing the charge of powder and shot. Much surprise resulted from the comparison of 8lb. with 2400lb.; but it can scarcely be said that the public were greatly enlightened when the comparison was made. In recent days somewhat similar effects appear to have been reproduced, but they must be alluded to hereafter.

Some five or six years since, experiments were carried out by Major McClintock, to ascertain the amount of force generated in military rifles. He took the pressure just in front of the cartridge case, by means of a lead crusher-gauge; and in a Snider-Enfield rifle, with 2½drs. of powder and the 480grs. bullet of ·577 bore, he estimated the pressure at from 2 to 2½ tons per square inch; while the Martini-Henry rifle, with about 3drs. of powder and the 480grs. bullet of ·450-bore, gave a much higher pressure, which he estimated as equivalent to 4½ to 5 tons per square inch. Subsequently he made other experiments, in connection with the Birmingham Proof-House trial; but, as these were mostly with large charges such as are used in proof, it is needless here to dwell upon them, except to state that where a 3drs. charge was fired with 1⅛oz. of shot in a 12-bore barrel (the powder being of the same kind as used in the Martini-Henry rifle, viz., R.F.G.[2], which is very similar to C. & H. No. 6), the pressure was estimated by Major McClintock at about 24401b., or rather over a ton to the square inch, and consequently only about one-fourth as high as in the ·450 rifle barrel with the resistance of the long bullet.

Mr. Walsh's experiments with lead cylinders made no pretence to record any pressure in pounds; they merely showed the different visible effects produced by different kinds of powder.

About two years since, Mr. R. W. S. Griffith, the manager of the Schultze Gunpowder Company's works, carried out a very extensive series of experiments with different powders and various charges, the pressures being taken by means of lead crusher-gauges in barrels of 12-bore and 20-bore. A long article was published in our impression of Nov. 20, 1896 [here reprinted at page 29, *et seq.*], including detailed particulars and illustrations of the apparatus used, together with some of the results that had been obtained. Other records, which were made at the same period, have not yet been published, and we propose to insert them later on; but in the present article we shall notice only a few of the most salient features. Mr. Griffith's figures, as will hereafter be seen, are not so high as those of some other experimenters; but this is evidently due to the fact that, in framing his scale, he adopted the method of allowing a dead weight to remain upon the lead until the disc ceased to be reduced by the pressure; whereas other experimenters have only allowed the weight to act for a very brief period, and a much heavier pressure was consequently required to produce an equal effect. This difference of procedure will suffice at once to explain some of the apparent discrepancies between the records of different scales.

The experiments by Mr. Griffiths, above alluded to, are the only ones yet made known that afford a distinct idea of the relative amount of pressure produced by charges fired in 20-bores, as compared with those fired in 12-bores. His full records we will defer for the present, but we may here give the results of the same quantity of powder and shot being fired from the two barrels. How the strain of the various powders differs in both bores may be seen at a glance in the following table, which states not only the highest record of each, but also their percentage of variation from No. 6 grain. This percentage applies, in each instance, to the different powders in the same barrel; and it will be observed that, while the quick-burning powders exert in the 12-bore a much higher pressure than the coarse No. 6, this increase of force is intensified in the narrow gauge, where the percentage always rises higher than in the larger bore, except as regards Schultze—which powder, although increasing its strain in the small barrel, nevertheless, in consequence of the comparative slowness of its ignition, produces much less pressure in the 20-bore than either of the black powders named in the table. In both barrels the charge was the same, viz., 3drs. and 1oz.

Powder.	12-Bore.		20-Bore.	
No. 6. T.S....	1514.....	.....	2834.....	
	Difference from No. 6.		Difference from No. 6.	
No. 4	1910, or increase of 26 p.c.	.....	4050, or increase of 43 p.c.	
No. 3	2449,	62 ,, ...	4923,	74 ,,
No. 2	3317,	119 ,, ...	6755,	138 ,,
Schultze ...	1770,	17 ,, ...	2560, or decrease of	10 ,,

Mr Griffith is reticent as to the differences of pressure with nitro-compounds other than Schultze; for, whatever information he may find it necessary to obtain for his own business purposes, the particulars he enables us to lay before our readers are merely such as go to show the differences of character that distinguish the two separate classes of explosives, without anything indicative of the rivalry that may be supposed to exist between competitors in the same class of manufacture. Fortunately, however, the public are not left altogether in the dark by this course of procedure; for, as we have hereafter to show, a somewhat similar set of experiments, though on a less extensive scale, has recently been carried out by Messrs Curtis and Harvey, who record the pressures given by several nitro-compounds, but include none of black powder other than of their own manufacture.

It will doubtless be remembered that last summer (1887) Messrs. Curtis and Harvey brought out a pamphlet in which they gave the results of experiments carried out at their works at Hounslow. In the autumn of last year they likewise made further experiments, particulars of which are given in a second edition of their pamphlet. We shall make further allusion to these experiments later on, but here we may briefly mention that Messrs. Curtis and Harvey's scale is numerically just about 2½ times as high as Mr. Griffith's, though the relative proportions keep closely together. As was remarked in a notice of Messrs. Curtis and Harvey's pamphlet, in the *Field* in July last, "For the mere purpose of drawing conclusions as to the comparative amount of pressure exhibited by different powders, it would matter little which of these scales were adopted, supposing that only one were in use; but, both being in operation, they would conflict greatly if the figures obtained by the two methods were set forth without any explanation." To show how the two scales run together, we give a short comparative table of highest pressures registered by the only powders tried in both sets of experiments; and it may also be mentioned, as explanatory of the lower pressure with No. 6 in Mr. Griffith's experiments, that he used equal quantities of the two black powders, whereas Messrs. Curtis and Harvey used, of No. 6, 4grs. more than of No. 4, with the view of imparting equal velocity to the shot. As the last-mentioned firm had two sets of experiments with Schultze, we give here the average of the two.

	High Scale.		Low Scale.	
Powders.	C. & H. Data unaltered.	Griffith's Data multiplied by 2½.	C. & H. Data divided by 2½.	Griffith's Data unaltered.
C. & H. No. 4	5273	5225	2109	2090
,, No. 6	4289	4085	1716	1634
Schultze	4722	4775	1889	191

Mr. Edgar Harrison, of the well-known firm of Messrs. Cogswell and Harrison, has likewise been conducting experiments with lead crusher-gauges, which gave results that are numerically a little below those of Messrs. Curtis and Harvey.

Experiments have also been carried out by Mr. S. B. Allport, chairman of the Birmingham Proof-House Board, by means of falling weights and spiral springs, as well as with lead plugs. His pressures (recorded in *Land and Water* of Nov. 26, 1887) are given as "foot-pounds per square inch;" the other experimenters estimate theirs in ordinary "pounds per square inch." The black powders used by Mr. Allport were of Messrs. Pigou and Wilks's make, while the rest of the experimenters used Messrs. Curtis and Harvey's. The charges generally adopted were 3drs. of powder with 1¼oz. of No. 6 shot; but, as previously mentioned, Messrs. Curtis and Harvey slightly varied theirs with the size of grain, allowing 2grs. more for each increase of size. In all cases the charges of E.C. or Schultze was 42grs., but only 40grs. were used of Cooppal. The following table will show the highest figures in each set of records with powders that were used by more than one experimenter:

	Messrs. Curtis and Harvey.	Messrs. Cogswell and Harrison.	Mr. Griffith.	Mr. Allport.
	lb.	lb.	lb.	ft.-lb.
No. 2 Black	—	6410	3430	186
No. 4 ,,	5273	4950	2090	—
No. 6 ,,	4259	4036	1634	66
Cooppal	5981	—	—	174
E.C.	4838	4760	—	96
Schultze	4723	4740	1910	84

It will here be seen that Mr. Allport's records are nearly as wide apart from those of Messrs. Curtis and Harvey, as Mr. Walsh's 8lb. was from the pressures recorded by Messrs. Hall. Yet, however the results may be stated in figures, the actual facts must be pretty much alike. If equal charges be fired from barrels of the same dimensions, there cannot be any very material difference in the pressures really produced, however widely divergent they may appear when represented in pounds or foot-pounds as given above. By using the latter expression, and treating the pressures as energies, the difficulty is not overcome, but rather intensified. However, it is possible to form a tolerable notion of what force must be exerted in the barrel to accomplish the work that is done; and in this way, although one may not be able to calculate exactly what is the highest strain, the lowest possible pressure can be found without much difficulty. This, however, can scarcely be done at the fag end of the present article, and so must be left for consideration on a future occasion; and we can now merely remark that Mr. Griffith's pressures appear to be under, rather than over, the full force likely to be exerted in the barrel; but, if such be the case, how very inadequate must be those of Mr. Allport to represent the amount of work that is actually performed by the powder.

(*Field*, April 7, 1888; Vol. 71, p. 500.)

In a previous article (reprinted above) it was mentioned that further particulars would be given with respect to experiments carried out for the purpose of ascertaining the amount of pressure exerted by explosives in the barrels of sporting guns. The most extensive series of records is that made by Mr Griffith, of which some details were published in *The Field* of Nov. 20, 1886; and we now add others, with powders not included among those previously published.

First of all (as the comparison between the nitro-compounds and black powder is usually based on No. 4 Treble Strong), we give a table showing the pressures of Curtis and Harvey's No. 4 T.S. as compared with corresponding charges of Schultze, in the 12-bore barrel, with different quantities of powder and shot. The columns of figures show the pressures at three plugs in pounds per square inch of Mr Griffith's scale:

	BLACK (No. 4).			SCHULTZE.		
12-Bore.	1 inch.	2½in.	6in.	1 inch.	2½in.	6in.
2½drs. and 1oz.	1640	1448	916	1124	1030	858
,, ,, 1¼oz.	1760	1616	964	1304	1409	958
3drs. and 1oz.	1910	1790	1040	1768	1770	1030
,, ,, 1¼oz.	2090	1796	1046	1850	1910	1067
3½drs. and 1¼oz.	2800	2280	1160	1962	2414	1222
,, ,, 1½oz.	3110	2621	1228	2444	2684	1257
4drs. and 1½oz.	3770	3210	1321	3063	3120	1352

The three plugs are 1 inch, 2½in., and 6in. from the breech, and consequently the first and second are 1½in. apart, and the second and third are 3½in. apart, as was shown in the illustration given in the article above mentioned. At these same plugs the pressures with C. & H. No. 2, No. 3, and No. 6 powders were as follows:

	BLACK (No. 2).			BLACK (No. 3).			BLACK (No. 6).		
12-Bore.	1in.	2½in.	6in.	1in.	2½in.	6in.	1in.	2½in.	6in.
2½drs., 1oz.	2385	1805	964	1747	1605	948	1149	986	861
,, 1⅛oz.	2795	2064	1034	2015	1747	996	1272	1060	865
3drs., 1oz.	3317	2350	1067	2449	1930	1039	1514	1434	921
,, 1⅛oz.	3430	2385	1090	2900	2065	1067	1634	1548	980
3½drs., 1⅛oz.	4421	3223	1179	3395	2580	1162	1838	1730	1028
,, 1¼oz.	4948	3309	1196	3960	2756	1209	2106	1799	1058
4drs., 1¼oz.	6720	4816	1261	4948	3602	1314	2480	2200	1166

In 20-bore guns, the pressures, as compared with the charges used, are much greater than in the 12-bore. In order to perform in a small-bore the same amount of work as is done in a larger barrel, there necessarily must be a higher pressure; because the base of the bullet in a rifle, or the wad behind the shot in a smooth-bore, is reduced in area in the smaller barrel, and, if the same weight of lead has to be propelled, there must be more force applied to the small area in order to impart equal velocity to the shot. Supposing the same charge of 3drs of powder and 1oz. of shot were used in a 12-bore and in a 20-bore, the force applied to the smaller wad must be 40 per cent. higher than on the other, in order to give the same speed, without making the slightest allowance for increased friction. But there is very great additional friction; and this so impedes the movement of the shot, when the powder is ignited, that the extra force developed is very much greater than that above stated. If a comparison be made between the 3drs. and 1oz. charge in the following table, and the same charge in the 12-bore table above, it will be seen that, with No. 4 powder, the pressure is raised from 1910 to 4050, or an increase of 112 per cent. With the slower-burning Schultze, more time being allowed for the shot to be set in motion, the rise is not nearly so great as with black powder, but there nevertheless is an increase of about 45 per cent.

	BLACK (No. 4).			SCHULTZE.		
20-Bore	1 inch	2½in.	6in.	1 inch	2½in.	6in.
2drs. and ½oz.	2001	1600	912	1227	1323	850
,, ,, ⅞oz.	2240	1767	980	1418	1488	928
2½drs. and ⅝oz.	2542	1790	1006	1550	1627	1022
,, ,, ⅞oz.	2825	2015	1080	1772	1890	1046
3drs. and ⅞oz.	3520	2676	1171	2140	2290	1162
,, ,, 1oz.	4050	3063	1200	2182	2560	1226
3½drs. and 1oz.	5200	3620	1279	2676	2960	1322

In the next table may be traced the differences of effect of slow and rapid explosion of black powders in the 20-bore, as compared with the 12-bore results given in the second table above.

	BLACK (No. 2).			BLACK (No. 3).			BLACK (No. 6).		
20-Bore.	1in.	2½in.	6in.	1in.	2½in.	6in.	1in.	2½in.	6in.
2drs., ½oz.	2658	1735	865	2236	1638	892	1354	1265	795
,, ⅞oz.	2965	1795	936	2524	1735	948	1462	1371	834
2½drs., ⅝oz.	3410	2090	1014	2825	1923	1014	1708	1472	912
,, ⅞oz.	4170	2657	1078	3188	2284	1086	1876	1592	974
3drs., ⅞oz.	5870	3630	1293	4240	2892	1219	2650	2090	1219
,, 1oz.	6755	3780	1310	4922	3395	1228	2834	2324	1293
3½drs., 1oz.	7560	4350	1379	6250	3738	1330	3095	2686	1276

Taking the charge of 3drs. and 1oz., the pressure from the finest grain (No. 2) in the 20-bore is more than double that in the 12-bore, *i.e.*, at 1 inch from the breech, whereas at 6in. it is only 24 per cent. higher. On the other hand, with coarse grain (No. 6), the excess over the 12-bore at 1 inch is but 60 per cent., and the fall less rapid. Hence it is best to use slow-burning powders in guns of narrow bore.

Messrs. Curtis and Harvey's experiments have also been previously alluded to, and we gave some particulars about them when the first edition of their pamphlet was issued last summer. Afterwards they carried out a second series of experiments, but did not adopt the same course of procedure in both trials, as will be seen by the following quotation from the new edition of their pamphlet:

In the first series, undertaken in the early part of 1887 and described in the first edition of this book, the gunpowder used was obtained directly from the mills at Hounslow and loaded by ourselves, while the Schultze and E.C. cartridges were purchased ready loaded from one gunmaker. These latter powders were presumably loaded by the same hand, and derived respectively from one and the same batch or "issue." In the second series, all the cartridges fired—of black as well as of white powder—were purchased ready loaded, and, excepting the Cooppal powder, which is not so easily procurable, one-fourth only of the number of each kind required

were obtained from one gunmaker, so that the loading of four different persons was brought into the test. Moreover, six months having elapsed between the completion of the first and the commencement of the second series, the powders would probably be of different "issues." The change from the method followed at the outset of these experiments was made—first to ensure all conditions prevailing in actual practice, and, next, to avoid the possible reproach of having made a selection unfavourable to the nitro-compounds.

The pressures were taken by two plugs, the first at 1 inch from the breech, and the second at 2½ in. (there not being a third plug). No black powder of finer grain than No. 4 is recorded in either set of experiments; and the autumn trials included only one variety of black (No. 4 Diamond grain), together with Cooppal powder and new issues of both Schultze and E.C. The charges used were 42grs. each of E.C. and Schultze, 40grs. of Cooppal, 82grs. of No. 4 black, 84grs. of No. 5, 86grs. of No. 6, and 87grs. of brown—in each case with 1⅛oz. of No. 6 shot. The variations in the charges of black powder were adopted as being those which would be likely to impart equal velocity to the shot. The following table will give a bird's-eye view of the general results—the figures representing pressures in pounds per square inch, according to Messrs. Curtis and Harvey's scale:

12-Bore.	Spring Trial. 1 inch.	Spring Trial. 2½in.	Autumn Trial. 1 inch.	Autumn Trial. 2½in.
C. & H. No. 4 T.S.	5273	4640	—	—
„ No. 4 Diamond grain	—	—	4975	4630
„ No. 5 T.S.	4740	4570	—	—
„ No. 6 „	4289	4119	—	—
„ Brown	3838	3787	—	—
Schultze	4505	4740	4378	4703
E.C.	4418	4640	4667	5085
Cooppal	—	—	5544	5961

We regret that there were no experiments with the black powders of finer grain, as they would have enabled a better comparison to be made between two different scales, and it could then have been seen whether they ran in parallel lines at the high pressures as well as the lower; for, if so, as Messrs. Curtis and Harvey's scale is about 2½ times as high as Mr. Griffith's, their record with No. 2 T.S. powder would stand at about 8500lb. per square inch in the 12-bore and about 17,000lb. in the 20-bore.

Mr. Edgar Harrison (of the firm of Cogswell and Harrison), by means of his 12-bore crusher-gauge apparatus, obtained the following records from 3drs. of the black powders, and 42grs. each of E.C. and Schultze, with 1⅛oz. of shot, at the distances from the breech here stated:

	1in.	2½in.	5½in.
No. 2 Diamond grain	6410	5570	3280
No. 4 T.S.	4950	4520	3800
No. 6 „	4096	3996	2649
E.C.	4760	4460	3690
Schultze	4550	4740	2840

Mr. S. B. Allport, in the experiments which he has carried out, had in view the ascertaining of the pressures at a greater number of points than any of the previous experimenters. His records were taken at six different points in a 12-bore barrel, viz., 1 inch, 2½in., 6in., 9in., 15in., and 21in. from the breech. Two kinds of black powder were used, viz., No. 2 and No. 6 grain, of Messrs. Pigou and Wilks's make, the charge being 3drs. with 1⅛oz. No. 6 shot. Three nitro-compounds were also tried, the charge of E.C. and Schultze being 42grs. each, and that of Cooppal 40grs. The recorded pressures, in "foot-pounds per square inch" of Mr. Allport's scale, were as follows:

	1 inch.	2½in.	6in.	9in.	15in.	21in.
No. 2 Black	186	92	29·4	12·7	2·0	0·33
No. 6 „	66	45	18	9·5	1·6	0·3
Schultze	84	44	18·6	11·4	0·66	—
E.C.	96	74·6	31	13·7	2·0	—
Cooppal	174	84	24·7	12·7	2·3	0·66

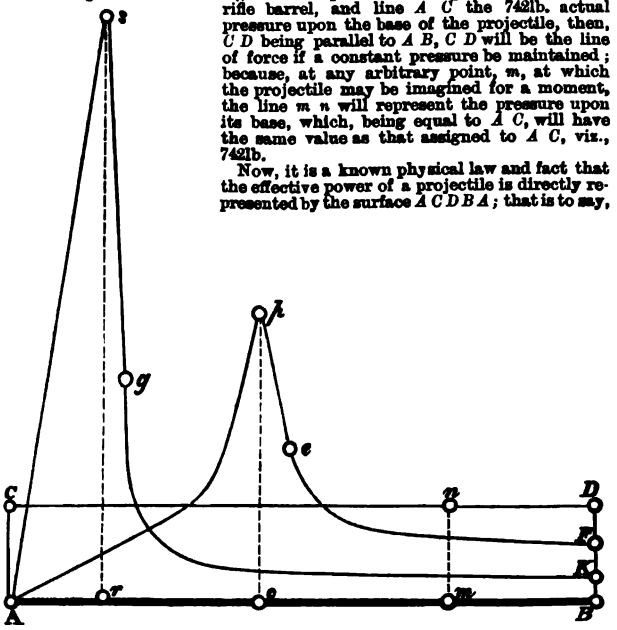
Whatever opinion may be formed as to which of the various scales approaches most nearly to accuracy, it seems obvious, as previously remarked, that Mr. Allport's records must fall far below the real pressures in the barrel. The work actually performed by the propulsion of the shot could not be effected without a much greater application of force than the above figures would appear to indicate. Instead, however, of attempting to demonstrate this by remarks specially framed to meet this particular case, we prefer to quote what was written more than twenty years ago by Mr. J. J. Révy, C.E., a gentleman who was assistant to Baron von Lenk in experiments carried out for the Austrian Government, and had great knowledge of explosives and their characteristics. Writing in the *Field* of Sept. 8, 1866, on the operation of cartridges in guns, Mr. Révy made the following remarks, which are applicable to present circumstances as well as to those then under consideration:

Before going into the mode of trial by which the relative merit of two cartridges may be tested, it is necessary, in order to clearly understand such trial, to explain the mode of proceeding by means of diagrams. Let us take, for instance, the Enfield rifle, and examine the operation of a cartridge in it.

The bore of the rifle being ·577, length of barrel 39in., weight of projectile 530grs., standard initial velocity of projectile say 1400ft. per second, we find, after a very simple calculation, that, allowing 37½in. for the motion of the projectile in the barrel (1½in. being occupied by the charge), the mean pressure upon the base of the projectile during the distance of 37½in., to produce 1400ft. velocity, must be 7421b., or 28371b. per square inch, or 189 atmospheres mean pressure or tension of gas continually exerted upon the base of the projectile. The actual pressure in the rifle is somewhat higher, on account of friction against the barrel and the spinning motion of the projectile.

Assuming *A B* in the diagram to represent the 37½in. of the Enfield rifle barrel, and line *A C* the 742lb. actual pressure upon the base of the projectile, then, *C D* being parallel to *A B*, *C D* will be the line of force if a constant pressure be maintained; because, at any arbitrary point, *m*, at which the projectile may be imagined for a moment, the line *m n* will represent the pressure upon its base, which, being equal to *A C*, will have the same value as that assigned to *A C*, viz., 742lb.

Now, it is a known physical law and fact that the effective power of a projectile is directly represented by the surface *A C D B A*; that is to say,



if that surface be increased or decreased, either by increase or decrease of the mean pressure or of the length of barrel, the effective power is also correspondingly increased or decreased; and we may simply take that surface as the *measure* of the effective power of cartridge or projectile.

It will now be readily understood that if the force and tension of gas be not constant, but variable, then another line—for instance *A p o F*—may represent such variable force.

At a point *o* of the barrel, let the line *o p* represent the maximum pressure or tension of gas, from which point the pressure may irregularly decrease. If the surface *A p o F B A* be equal to the former surface, then the measure of the effective power of the cartridge will be the same as before.

Assuming *A s g K* to represent another curve of force, and that at a point *r* the maximum pressure upon the projectile be represented by *r s*, and suppose this curve to form the same superficial area with the line *A B* as the first and second line of force, then the measure of the effective power of the cartridge will again be the same as before.

We have now three different lines of force—the first being represented by *C D*, the second by *A p o F*, the third by *A s g K*—all of which will produce the same effect, and therefore, with similar projectiles, equal velocities. But is not the strain to which the rifle is subjected entirely different in each case?

The maximum pressure in the first case is represented by *m n*, equal to 742lb., or 189 atmospheres; in the second by *o p*, or 2226lb., or 567 atmospheres; in the third by *r s*, or 4452lb., or 1134 atmospheres; and if the gun was safe with *o p*, it by no means follows that it would be so with *r s*.

Now let us consider the constant pressure requisite to effect the work done in an ordinary 12-bore gun by a charge of 3drs. of powder with 1⅛oz. of shot. The calculation is, as Mr. Révy said, a simple one; but, as it may not be familiar to all our readers, we will briefly explain the process, without entering into details as to the principles upon which it is based. It consists merely of multiplying the weight of the shot by the square of its velocity, and dividing by 64 (*i.e.*, twice the accelerating force of gravity). With the charge just mentioned, the muzzle velocity may be taken, in round numbers, as

1200ft. per second; the weight of shot is equivalent to ·071b; and on multiplying ·07 by 1200 times 1200, and then dividing by 64, we get 1575 foot pounds as the amount of energy imparted to the charge of shot. Moreover, the area of the 12-bore being only a trifle over four-tenths of a square inch, this energy in a charge of that calibre is equal to about 3750 ft.lb. per sq. in. On dividing 3750 ft.lb. by the length of barrel (2½ft.), it will be found that, to impart this amount of energy, there would be required a force equivalent to a constant pressure of 1500lb. per square inch acting throughout the whole length of a 30in. barrel—without making any allowance for friction, or for the space occupied by the charge. This 1500lb. per sq. in. would represent the constant or mean force indicated by the parallelogram *A C D B* in Mr. Révy's diagram; and, inasmuch as there is a very great dwindling away of force as the shot proceeds from one end of the barrel to the other, it necessarily follows that near to the breech there must be some such pressure as is indicated by the lines *o p* or *r s* (according to the nature of the powder used), and that it must so far exceed 1500lb. per sq. in. as will suffice to make up for the reduced pressure towards the muzzle, and bring the whole up to the general average.

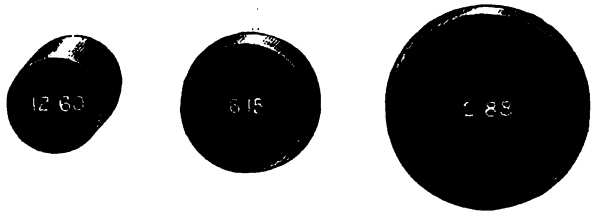
Now, looking at the figures in the last table, seeing what they begin with at 1 inch from the breech, and what they dwindle down to at 21in., it does not seem feasible that the shot could acquire therefrom the impulse that it is known to receive. The apparent mystery, however, appears to result from the scale being based on the amount of compression produced by falling weights; and upon this subject we propose to make a few remarks in a future article.

(*Field*, April 21, 1888; Vol. 71, p. 580.)

In remarking on the widely divergent statements that have been made at various times with respect to the pressure of powder gases in gun-barrels, we said (page 43) that we would try to ascertain whether a certain amount of harmony might not be found among records that appear to be greatly in conflict. We alluded, in the first place, to experiments carried out some years ago by Mr. Walsh, in which, by dropping a weight of seven or eight pounds the distance of one foot, effects were produced very similar in character to those caused by firing off an ordinary charge of powder and shot, although, by a crusher-gauge record, the force exhibited was estimated at about 2400lb. per square inch. The difference between seven or eight pounds and a weight of more than a ton appears marvellous to those who are not apt to consider the difference between foot-pounds and pounds without the prefix. In the ordinary or static pound, when it really is what it professes to be, there is a definiteness which everybody can appreciate; whereas the foot-pound has a shiftiness which is bewildering to most people, as it may mean almost any intensity or feebleness of pressure, according to the space or time during which the force is in operation. The energy generated, say, by a pound ball falling a foot may be exhausted in a long or a short distance. If the ball is made to take a horizontal direction, and meets with little obstruction on reaching the ground, it may roll a great way, and the constant or average resistance it has met with may be estimated from the distance it has run; if suspended by a string, so that it will act like a pendulum, it will rise against its own weight to practically the same distance it has fallen; or, if it be stopped in less than a foot, the resistance must exceed its own weight in inverse proportion to the space traversed. Thus, if stopped in an inch, instead of a foot, the foot-pound of energy would require a constant resistance of 12lb. to exhaust it in that space; if stopped in a tenth of an inch, the pressure would be 120lb., and so on. Hence, if Mr. Walsh's 8lb. weight were stopped in the tenth of an inch, or the 120th part of a foot (which, in round numbers, was about the space traversed), it would have encountered a resistance equivalent to a pressure of about 960lb. for the brief period during which it was brought to a stop. This amount of pressure, in the area of a 12-bore, would be equal to rather over a ton per square inch; consequently it closely approaches the pressure estimated by the crusher-gauge, previously by Messrs. Hall and Son, and subsequently by Major McClintock. Here, then, we get an example of eight foot-pounds being an equivalent for a pressure of a ton per square inch, for a very brief period of time, or a very limited distance; but it is much more easy to measure the distance than to measure the time.

More recently we have had records made by several different crusher-gauges, all of which ostensibly gave their records in static pounds, although they differed considerably in their scales. Now, in many other matters it is easy to convert one scale into another. English pounds, or inches, or miles, may be converted into German pounds, &c.; or degrees of temperature may be changed from Fahrenheit to the Réamur or Centigrade scales; but in these cases there are datum lines upon which the scales are based, whereas with the crusher-gauges there appears to be no common datum line. The different experimenters may all make use of avoirdupois pounds, but they apply them for various periods of time on masses of lead that are not of equal dimensions. Even when the dimensions are the same, the duration of the pressure considerably affects the result.

It was mentioned, in our impression of April 7, 1888, that Mr. Griffiths had sent us some tables giving the results of experiments in testing the effect of the action of dead weights when allowed to rest upon lead crusher-gauges for different periods of time. The crusher-gauges in this case are short cylinders of lead, half an inch long (in millimetres they measure 12·60mm. in length, 12·65mm. in diameter, and weigh 18·07 grammes, or 279 grains). The plug in the pressure apparatus has a diameter of ·618in., equal to three-tenths of a square inch, so that, to bring measurements of lead crushers into correspondence with pounds per square inch in the pressure apparatus, the dead weights used must be multiplied by 10/3. When submitted to pressure—whether it be by dead weights resting upon them, or by the action of powder-gases in a gunbarrel—the force crushes down the lead, and thus simultaneously reduces it in length and increases the surface area, as shown in the accompanying figures, where the one marked 12·60 represents a lead that has



not undergone compression, while the next has been squeezed down to 6·15mm., thereby reducing its height by 6·45mm., and the third has been crushed down to 2·88mm. or a reduction of 9·72mm.

The crushing effect produced by the action of the powder gases is nearly instantaneous; but dead weight pressures cannot be put on and taken off so rapidly as to give the same result. The question therefore arises, as to what time should be allowed for the weight to act upon the lead. In one of the tables sent us by Mr. Griffith he shows the differences of effect caused by the same weights acting for various periods of time, and different weights acting for equal periods. It will be seen that a dead weight of 100lb. on the lead above described (equivalent to a pressure of 333lb. per square inch) has no effect whatever in less than one-tenth of a second; after that, compression goes on gradually, but makes very slow progress after the lapse of an hour; with heavier weights it is still more slow at the end, though quicker at the beginning.

COMPRESSION OF LEADS BY WEIGHTS ALLOWED TO REST FOR DIFFERENT PERIODS OF TIME.

Dead weight on lead.	Equivalent in lbs. per sq. inch.	sec. ·01	sec. ·05	sec. ·10	sec. ·50	sec. 1·0	min. 1	min. 5	hour. 1	hrs. 24
lb.	lb.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
100 ...	333 ...	·00	·00	·01	·01	·02	·10	·14	·22	·30
200 ...	666 ...	·00	·01	·04	·08	·10	·17	·21	·53	·88
300 ...	1000 ...	·00	·14	·21	·28	·33	·38	·43	1·25	2·21
400 ...	1333 ...	·01	·31	·49	·58	·62	·76	1·00	3·20	4·00
500 ...	1666 ...	·02	·45	·79	·96	1·08	1·34	1·90	4·94	5·60
600 ...	2000 ...	·03	·58	1·09	1·41	1·59	2·35	3·50	6·20	6·67
700 ...	2333 ...	·04	·67	1·37	1·93	2·14	3·57	4·92	6·89	7·30
800 ...	2666 ...	·05	·73	1·61	2·53	2·84	4·70	5·85	7·42	7·78
900 ...	3000 ...	·06	·79	1·81	3·27	3·80	5·65	6·62	7·90	8·22
1000 ...	3333 ...	·07	·84	1·98	4·02	4·84	6·47	7·28	8·33	8·61
1200 ...	4000 ...	·09	·94	2·29	5·30	6·20	7·54	8·18	8·96	9·18
1400 ...	4666 ...	·11	1·04	2·56	6·38	7·12	8·21	8·76	9·34	9·52
1600 ...	5333 ...	·14	1·12	2·80	7·32	7·90	8·78	9·25	9·65	9·79
1800 ...	6000 ...	·17	1·20	3·02	8·01	8·46	9·22	9·61	9·88	9,99
2100 ...	7000 ...	·20	1·32	3·31	8·77	9·12	9·76	10·02	10·16	10·24
2400 ...	8000 ...	·23	1·44	3·56	9·29	9·60	10·12	10·32	10·35	10·39
2700 ...	9000 ...	·26	1·53	3·76	9·67	9·94	10·34	10·46	10·48	10·51
3000 ...	10,000 ...	·29	1·60	3·94	9·92	10·16	10·44	10·54	10·58	10·62

In a letter from Mr. Griffith, recently published, he states the reasons which led him to adopt the period of twenty-four hours' rest of weights in preference to a shorter amount of time; and in a

note accompanying the tables he gives the following illustration of the difference of record made by varying the time:

Take an instance of the effect produced by the action of 3drs. of No. 4 black powder with 1¼oz. of No. 6 shot. This compresses the lead to 5·76 mm. (equal to a reduction of 6·84 mm. in the above table), and by my "final compression" table of twenty-four hours represents a pressure of 2090lb. per square inch. If, however, the weights be only allowed to remain on for shorter periods, the difference in the figures would be as follows:

If weight remains 24 hours	.....	2090lb.	per sq. inch.
,, ,, 1 hour	.....	2300	,, ,,
,, ,, 5 minutes	.....	3100	,, ,,
,, ,, 1 minute	.....	3500	,, ,,
,, ,, 1 second	.....	4450	,, ,,
,, ,, 5 seconds	.....	5000	,, ,,

While under a tenth of a second the amounts would be enormous.

It is not surprising, therefore, if different experimenters allow the weights to remain on the lead for different periods of time, that their records are widely apart in the numerical results.

Besides carrying out experiments with stationary weights, Mr Griffith has also tested the effects of dropping weights on lead crusher-gauges similar to those described above. We need hardly mention that, when energies are stated in foot-pounds, the figures represent the amount of force generated either by the weight mentioned being dropped the distance of one foot, or by more or less weight being dropped other distances. Thus, 20 foot-pounds will represent either a 20lb. weight dropped 1ft., or a 10lb. weight dropped 2ft., or a 60lb. weight dropped 4in. But when such weights are dropped on lead crusher-gauges, or on spiral springs, or anything which presents an increasing instead of a constant resistance, then the effects produced by a given number of foot-pounds are not the same. This will be seen by the differences in the amount of compression shown in the following table, where all the measurements being in millimetres, a more ready comparison may be made than if the drop were given in feet and the reductions in thousandths of an inch.

COMPRESSION OF LEADS BY DROPPED WEIGHTS.

Drop in mm.	1lb. mm.	5lb. mm.	10lb. mm.	15lb. mm.	20lb. mm.	25lb. mm.	30lb. mm.
100	0·23	0·96	1·58	2·06	2·44	2·73	2·82
200	0·43	1·53	2·48	2·96	3·37	3·64	3·78
300	0·60	2·02	3·20	3·71	4·17	4·45	4·62
400	0·75	2·46	3·80	4·36	4·87	5·16	5·35
500	0·89	2·85	4·32	4·95	5·48	5·78	5·97
600	1·02	3·20	4·78	5·49	6·02	6·35	6·54
700	1·14	3·51	5·20	5·99	6·52	6·87	7·06
800	1·24	3·79	5·58	6·45	6·98	7·35	7·55
900	1·33	4·05	5·92	6·87	7·40	7·79	7·98
1000	1·41	4·29	6·23	7·25	7·78	8·19	8·38
1100	1·48	4·51	6·51	7·60	8·15	8·56	8·75
1200	1·54	4·72	6·77	7·92	8·49	8·86	9·09
1300	1·60	4·92	7·01	8·19	8·80	9·17	9·40
1400	1·65	5·11	7·23	8·43	9·08	9·45	9·68
1500	1·70	5·29	7·43	8·66	9·34	9·71	9·94
1600	1·75	5·46	7·62	8·88	9·58	9·95	10·18
1700	1·79	5·62	7·79	9·08	9·80	10·18	10·41
1800	1·83	5·77	7·96	9·27	10·01	10·40	10·63
1900	1·87	5·91	8·12	9·45	10·21	10·61	10·84
2000	1·90	6·04	8·29	9·62	10·40	10 81	11·04

We requested Mr. Griffith, a short time ago, to furnish us with some information as to the effect of dropping weights on lead crushers, as well as the dead weights for different times, and he kindly supplied the above particulars. In reference to the amount of weight and height of drop requisite to produce the same effect on the lead as is effected by 3drs. of No. 4 powder with 1oz. of shot (viz., 6·84mm. compression, as stated above), he says: "To produce the same result by a falling weight, 10lb. must fall 1225mm.; 15lb. must fall 890mm.; 20lb. must fall 775mm.; 25lb. must fall 675mm.; and 30lb. must fall 640mm." Now, these figures would, in round numbers, represent respectively about 120, 130, 150, 170, and 190 foot-pounds per square inch; and, consequently, it would appear that the effects of dropping weights on lead cylinders are not so uniform as could be wished, and, like Mr. Walsh's experiments of dropping weights on spiral springs, they leave much to be desired in the way of regularity, so far as the evidence goes at present.

We may state that our request for the above information was with the view, if possible, of finding a key to the results of the experiments made by Mr. S. B. Allport, to which we have previously alluded. We had read the report of his experiments with some interest, but found it deficient in information upon certain points, and, when conversing with that gentleman several months ago, we expressed a desire for further particulars, but, as he very courteously said he was not then prepared to commit himself to an explanation on the subject, we have attempted in other ways to get information that might enable us to bring his results into accord with those of other experimenters; for, as previously remarked, however the results may be stated in figures, the actual facts must be pretty much alike.

On looking over Mr Griffith's table, it seemed possible that it would afford a clue to obtaining an approximate result, although it could not be expected to meet all irregularities. We had tried the effect of dividing the number of foot-pounds by the extent of compression—which would be similar in principal to the process described in the first paragraph of this article. This had the effect of placing the highest pressures above 10,000lb. with No 2 black powder, 60001b. with E.C., 5478lb. with Schultze, and 4743lb. with No. 6 black—numbers which did not look disproportionate one to another, though they came out higher than we had looked for; but when the small degrees of compression were reached, this process did not work at all satisfactorily, as beyond a certain point the numbers ceased to decrease, or even rose slightly. We observed, however, on examining Mr Griffith's table, that, in various instances, the amount of compression increased nearly as the square root of the increase of weight or length of drop; *e. g.*, dropping the 10lb. weight a distance of 400mm. gave 3·80mm. reduction, while dropping it four times as far gave but 7·62mm., or just about double; and, again, dropping 5lb. 300mm. gave 2·02mm., while four times as much (20lb.), dropped an equal distance, gave 4·17mm. This appeared to be a likely consequence of the increased resistance arising from the flattening of the lead, and the corresponding enlargement of the base, as shown in the opposite page. We accordingly tried the process of dividing by the square root of the compression instead of the full amount; and here is a table showing in juxtaposition the results of the two processes, The first column gives Mr Allport's number of foot-pounds, the second his amount of compression in thousandths of an inch. The first process is to multiply the foot-pounds by 12 (as being the number of inches in a foot) and divide by the fraction of an inch of compression; the second process is the same, except that the division is by the square root of the compression. The final column states the powder, and the plug at which the record was made. Occasionally the same pressure was recorded by more than one powder, but there is not space to particularise all of them.

Ft.lb.	In.	Full number.	lb.	Square root.	lb.	Powder.
186	·222	186 ×12+·222=	10,054	...Do., with √·222=	4737	No. 2, 1in.
174	·217	174 ×12+·217=	9622	,, ,, √·217=	4483	Coop., 1in.
96	·192	96 ×12+·192=	6000	,, ,, √·192=	2629	E.C., 1in.
92	·189	92 ×12+·189=	5841	,, ,, √·189=	2539	No. 2, 2½in.
84	·184	84 ×12+·184=	5478	,, ,, √·184=	2350	Schul., 1in.
74·6	·175	74·6×12+·175=	5115	,, ,, √·175=	2140	E.C., 2½in.
66	·167	66 ×12+·167=	4743	,, ,, √·167=	1938	No. 6, 1in.
45	·133	45 ×12+·133=	4060	,, ,, √·133=	1481	No. 6, 2½in.
44	·136	44 ×12+·136=	3882	,, ,, √·136=	1432	Schul., 2½in.
31	·102	31 ×12+·102=	3647	,, ,, √·102=	1165	E.C., 6in.
29·4	·098	29·4×12+·098=	3800	,, ,, √·098=	1127	No. 2, 6in.
24·7	·085	24·7×12+·085=	3487	,, ,, √·085=	1017	Coop., 6in.
18·6	·066	18·6×12+·066=	3382	,, ,, √·066=	869	Schul., 6in.
18	·064	18 ×12+·064=	3375	,, ,, √·064=	855	No. 6, 6in.
13·7	·041	13·7×12+·041=	3647	,, ,, √·041=	812	E.C., 9in.
12·7	·043	12·7×12+·043=	3544	,, ,, √·043=	735	No. 2, 9in.
11·4	·036	11·4×12+·036=	3800	,, ,, √·036=	721	Schul., 9in.
9·5	·030	9·5×12+·030=	3420	,, ,, √·030=	658	No. 6, 9in.
2·3	·007	2·3×12+·007=	3943	,, ,, √·007=	330	Coop., 15in.
2·0	·006	2·0×12+·006=	4000	,, ,, √·006=	310	No. 2, 15in.
1·6	·005	1·61×2+·005=	3840	,, ,, √·005=	272	No. 6, 15in.
·66	·002	·66×12+·002=	3960	,, ,, √·002=	177	Coop., 21in.
·33	·001	·33×12+·001=	3960	,, ,, √·001=	125	No. 2, 21in.

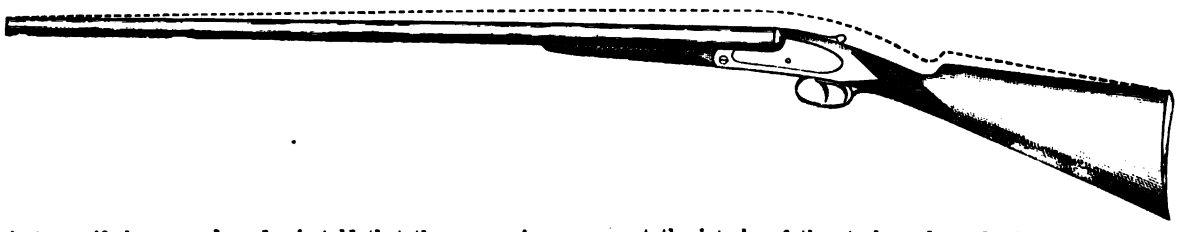
In this table it appears to us there is a fairly approximate representation of the real state of affairs. No pretence, however, is made to absolute accuracy; that could only be attained by a much more intimate knowledge of the details of every set of experiments than is at present forthcoming. The endeavour here has been merely to bring into accord, as far as possible, what seemed to be in almost hopeless discord; and it looks as though some approach to order may be evolved out of the apparent chaos.

Thus, the comparative table just given converts the results of Mr. Allport's experiments into pressures which are intermediate between the records of Mr. Griffith, on the one hand, and those of Messrs. Curtis and Harvey and Messrs. Cogswell and Harrison on the other,

and are likewise not very much higher than those of Messrs. Hall and Sons and of Major M'Clintock. Some of these gentlemen, however, tested the pressure only at one point of the barrel, Messrs. Curtis and Harvey at two, Mr. Griffith and Messrs. Cogswell and Harrison at three; but to Mr. Allport alone is due the credit of carrying out the experiments at half a dozen points, extending throughout the greater part of the length of the barrel.

Which of the systems tried will eventually prove the best adapted to meet all circumstances, the writer of these remarks does not pretend to determine. Having been present at Mr Walsh's experiments with dropping weights ten years ago, he has ever since had a strong desire to see this system more thoroughly worked out; but he has no particular prejudice for or against any method that will tend to elucidate the problem at issue. The results of his experience, so far as it goes, have led him to believe that absolute accuracy is very difficult to obtain, either with the dead weight or the dropping weight; but, if the latter should eventually prove the more reliable, it is to be hoped that its effects may be so recorded as to afford some more ready mode of comparison than energy in foot-pounds.

Pressure in ordinary pounds is understood by everybody, whereas energy in foot-pounds is not comprehended by one person in a hundred, and to the majority may be absolutely misleading. As has previously been remarked, the records in foot-pounds convey a very inadequate idea of the actual strain of the powder gases in the gun-barrel; and this remark was made, not with the intention of imputing inaccuracy to the records themselves, but to indicate the effect which the respective figures have upon the minds of most people who look at them. Everybody may be able to compare between 5000, 500, or any other numbers, if stated as pressures in ordinary pounds, because the pressure is taken as a definite expression of force, whether it is in operation for a long or a brief period of time; whereas the foot-pound is an indefinite expression, in so far that it represents a combination of force and time, and may mean either an accumulation of low pressures for a long time, or high pressures for a short time, or a combination of both.



For instance, if the general reader is told that the energy in a single pellet of No. 6 shot, when it leaves the muzzle of the gun, is over 5 ft.lb., and if he also sees the pressure of the powder gases on a charge of 304 such pellets, at 21in. from the muzzle, represented by 0·33, or one-third of a foot-pound per square inch, what definite idea would be likely to be conveyed to his mind? Or to take another instance, the highest record in the foregoing table, with No. 2 powder, at 1 inch from the breech, is represented as 186 ft.lb.; the lowest, with the same powder, at 21in. from the breech, is 0·33 ft.lb. Would not the ordinary assumption be, from a comparison of the two sets of figures, that the pressure from No. 2 powder, at two-thirds the length of the barrel, is less than the 500th part of what it was at the breech? Such, however, by no means represents the actual state of the case. If expansion of the gases alone had to be taken into consideration, the decrease of pressure would be in the proportion of about 1 to 20, instead of 1 to 500; but loss of heat, and other causes, would tend to a further diminution of force, and the difference between 125lb. and 47371b., as shown in the last column but one of the table, would probably give a more correct idea of the facts, the proportion here being about 1 to 40. How far this will stand the test of experience, when fuller particulars are forthcoming, remains to be seen; but we shall welcome any information which will tend to settle the matter beyond dispute, whatever be the method adopted, or whether it does or does not bear out what we have advanced.

In conclusion we may say, as we said at the commencement, but now altering the tense to meet the circumstances: "If we have ventured to point out what appears to us to be erroneous, we have not done so in anything like a carping spirit; for where men are honestly working to arrive at right conclusions, and incurring much trouble and expense in their endeavours to obtain satisfactory results, it ill becomes spectators to indulge in mere fault-finding. Captious criticism cannot be of advantage to anyone; whereas earnest endeavours to reconcile apparent antagonisms may not improbably result in the discovery of where the truth really lies." T.

SPRINGING OF STOCK—LIGHT GAME GUNS.

(*Field*, July 30, 1892; vol. 80, p. 171.)

We were recently shooting a light game gun at the target (the range being 40 yards), and were surprised to find that the centre of the charge of shot struck the target about 12in. low. The gun had 30in. barrels, and weighed 6lb. We afterwards obtained several light guns, some with 28in. and some with 30in. barrels, and invariably found the same thing occur. All the guns shot from 6in. to 12in. low, the charge being 3drs. of powder and 1⅛oz. of shot.

We frankly admit that, in spite of a fairly long experience, we were at first quite puzzled. However, nearly everything yields eventually to experiment, and this problem was no exception to the rule.

After a few trials it was found that the phenomenon was due to the recoil springing the "hand" of the stock, so that, while the charge was passing through the barrel, the stock became more bent, and therefore caused the gun to deliver its charge below the point aimed at. The dotted line in the accompanying woodcut shows, in an exaggerated form, what took place.

After pieces of wood had been glued to the "hand" of the stock, so as to prevent it springing, the charge was thrown perfectly true.

Of course, this kind of thing does not take place with a properly proportioned 7lb. gun, firing the usual charge; but only with light guns firing proportionately heavy charges.

A few years ago the standard weight for a 12-bore gun was 7lb., now it is only 6lb. 12oz.; and, in our opinion, if the gun is properly designed and used with smokeless powder, even this weight is more than sufficient to insure a pleasant shooting gun. But the weight must be put in the right place. For instance, what is the use of carrying about a solid block of wood for a stock, when the interior can be milled out, leaving a shell about a quarter of an inch in thickness and 10oz. lighter? Such a stock has precisely the same outward appearance as a solid stock, and is practically as strong. By milling out the interior of the stock we have about 10oz. to spare; and the question arises, what shall we do with it? Now the recoil of a gun is caused by the base of the cartridge pressing against the face of the breech action; therefore, if we wish to prevent excessive recoil in the best manner, we must concentrate all the available weight in the breech action. By so doing we shall accomplish two very desirable objects. In the first place, the breech action, by virtue of its weight, will be immensely strong, and therefore the various devices for holding the face of the action to the barrels will be unnecessary; and the recoil, instead of being transmitted through the hand of the stock and causing an unpleasant jar, will be at once absorbed, and the hand of the stock may be made small without its springing and causing the gun to shoot low.

In order to insure a thoroughly sound ejector gun, a *large* hole must be provided between the barrels, for the split extractor leg to work in; and, in order to provide sufficient room, the barrels should be jointed one tenth of an inch wider at the breech than usual. This change alone would require 4oz. more metal in the breech end of the barrels.

We will now compare the weights of the principal parts of an ordinary gun with a gun such as here proposed.

Ordinary Gun.	lb.	oz.	Proposed Gun.	lb.	oz.
Barrels, 12-bore, 30in.	3	0	Barrels, 12-bore, 30in.	3	4
Breech action, furniture, &c.	2	0	Breech action, furniture, &c.	2	6
Stock and wood fore-end	1	6	Stock and wood fore-end	0	12
Total weight	6	6	Total weight	6	6

If 6lb. 12oz. is not too heavy, the extra 6oz. should be put into the breech end of the barrels and the breech action, as it is more useful there than anywhere else.

We can assure our readers that we have not drawn upon our imagination for these particulars, as guns have been made on the above proposed lines, and have turned out highly satisfactory. P.

THE SPREAD OF PELLETS IN SHOT CHARGES.

(*Field*, April 9, 1887; vol. 69, p. 480.)

A CORRESPONDENT, writing from Ceylon some months ago, suggested that it would be interesting to obtain the pattern of a charge of shot as it reaches an object moving at the rate of sixty miles an hour, and he humorously added "Will some railway company supply a target?" Subsequently we received from Newfoundland a letter from another correspondent, making the suggestion that useful information might be obtained by fitting up a revolving cylinder as a target, and shooting at this whilst it was being spun round at a definite rate of speed. To procure such a target, and fit it up with the requisite machinery for working it and accurately regulating the speed, would be rather an extensive undertaking for merely carrying out the experiments suggested; but it fortunately happened that apparatus of a similar kind has been for some years in existence at the works of the Schultze Gunpowder Company, for the purpose of obtaining practical information in connection with the regularity of shooting of the powder manufactured at those works; and, being aware of this fact, we requested Mr. Griffith, the manager, to favour us with some particulars of the results he has obtained. That gentleman not only complied with our request for information, but carried it out far beyond our expectation by likewise preparing a series of illustrations of the shot patterns, copied by means of photography, in the practice of which he is an adept. We accordingly have much pleasure in laying before our readers reduced copies of these photographs, together with an illustration of the rotating target, which is kept in motion at a uniform speed by means of a steam engine employed upon the works. The accompanying text will furnish full details relative to the apparatus and the method adopted for ascertaining the velocity of the pellets, while the table will afford materials for comparison with respect to the velocities recorded with different charges from the same gun, at distances ranging from ten yards to sixty yards, as well as those of choke-bore and cylinder guns with equal charges.

In his earlier experiments, some years ago, Mr. Griffith first made use of a revolving cylinder for his moving target, but he found that the curved surface did not give altogether satisfactory results, as the pellets do not strike it on a true scale of arrival; and he accordingly discarded the cylinder in favour of a rotating disk. The advantage of the cylindrical form was that the dividing lines were parallel and the divisions all of the same size; but the radial lines, although not parallel, are perfectly readable and simple; for, whether the space between the converging lines be great or small, the period of time remains constant. And now, this preliminary over, we may lay before the reader Mr. Griffith's own description of his apparatus.

Description of Mr. Griffith's Rotating Target and Mode of Obtaining the Records.

To get patterns for photographing for your purpose, it was necessary to reconstruct my revolving target used for velocity purposes, and I send you with this a drawing of the target as used, which will, I hope, explain sufficiently the *modus operandi*.

The apparatus consists of a flat circular target, 12ft. in diameter, connected electrically with a chronograph, and kept rotating at a steady speed by steam power. For the purpose of simplifying calculations, I have run it at 318 revolutions per minute, thus giving a rim-velocity of 200ft. per second. The wheel is clad with a band 4ft. in width, and the rim is marked all round at distances 6in. apart, from which radial lines are ruled across the face towards the centre, every space at the above speed thus representing the 400th part of a second. Circular lines, 3in. apart, are also drawn on the face of the target, and by these lines the whole face is divided into sections, which can be numbered for reference; and for *velocity work*, so far as arithmetical records are concerned, these lines are all sufficient.

For visual inspection, however, the patterns thus obtained did not give such a good idea of the flight as a horizontal pattern would do; so, for my photographic purposes, the sections bounded by circular and radial lines were translated into sections of 6in. by 3in. on a surface with parallel lines, and, the pattern being carefully plotted out upon this horizontal method, the patterns were then photographed. Thus the photographs represent a horizontal translation of a pattern described in a section of a circle.

In front of the revolving target, as close as can be safely placed, is a fixed screen covering the whole of the lower half of the target, except that it is perforated with an opening 4ft. in diameter, so placed as to coincide with the 4ft. band rotating behind it. Across this opening, on the hinder side, is strained a sheet of very thin paper, which, on the gun being fired, gives the *stationary* pattern; while, after passing through the paper, the pellets reach the revolving target and give the *moving* pattern. The stationary patterns are photographed without any further trouble.

By whitewashing the fixed screen, one can tell whether the shot is a central one, and whether the bulk of the pattern has gone through the 4ft. aperture. If it is unevenly placed, the record is rejected. In my drawing (given on the following page) I have dotted in an imaginary pattern, as shown on the stationary paper screen (X) and on the revolving target (Z) behind, which is seen after it has made half a revolution.

So much for the apparatus. Now for results. The photographs sent are in three series:

Series 1 (see page 52): Results obtained from a choke-bore gun, No. 12 gauge, giving a close pattern, shot with 42grs. Schultze (equivalent to 3drs. black powder) and 1¼oz. of No. 6 chilled shot (304 pellets to the charge).

Series 2 (see page 54): Same gun, using 49grs. Schultze (=3½drs.), with the same quantity of shot as before, and giving a more open pattern.

Series 3 (see page 56): A 12-bore cylinder gun, with 42grs. Schultze and the same quantity of shot as before, and giving a very open pattern.

The three series were all tried at six ranges, from ten to sixty yards, and the circular photographs show the stationary pattern, while the rectangular photographs represent the moving pattern obtained with each. The number of pellets within the 4ft. circle is stated, and likewise that in a 30-in. circle. This gives all details required for the patterns.

Probably, however, you would like to know how I calculate velocities from such patterns. For this purpose I have drawn up a table of velocities, which I send herewith, and will explain how they are obtained. I have also marked on the central photograph of the series (40 yards range in Series 2, page 55) some lines that show my methods of calculating.

1. As to Scale.—The photographs are exactly $\frac{1}{12}$th scale, the 4 feet being reduced to 3·2in. [The scale has been further reduced in order to bring the photographs within the dimensions of the page, but lines are marked at the edge of the engravings to indicate what formed an inch in the photograph, and consequently each of these divisions may be taken as representing a space of 15 inches.—Ed.] The moving target running at 200 feet velocity towards the left, every foot towards the right on the target rim, or ·8in. on the photographs, means the loss of the 200th part of a second (·005sec.); and every inch on the photographs means a loss of time of ·00625sec. I append to the photograph (page 55) my scale for reading the measurements plotted out in this scale.

2. Where to start the Measurement.—The extreme left pellet cannot be taken as the first that strikes the target, because the gun throws the charge in a circle, and not in a perpendicular plane. Many experiments have convinced me that the first pellets consist of a group of about 5 per cent. of the entire charge. Many patterns show this distinctly; so I invariably take as the basis of measurement *a line drawn perpendicularly through the centre of the first 5 per cent. of the charge*,* amounting in these instances (with 1¼oz. of No. 6 shot) to the first fifteen pellets. This starting line represents the first arrival, and gives the chronographic result of *velocity of the fastest pellets*. On the marked photograph this is the centre between lines A and B. From this line any portion of the charge may be readily measured—always remembering that the centre of a group or cluster must be taken as the true velocity point of the group.

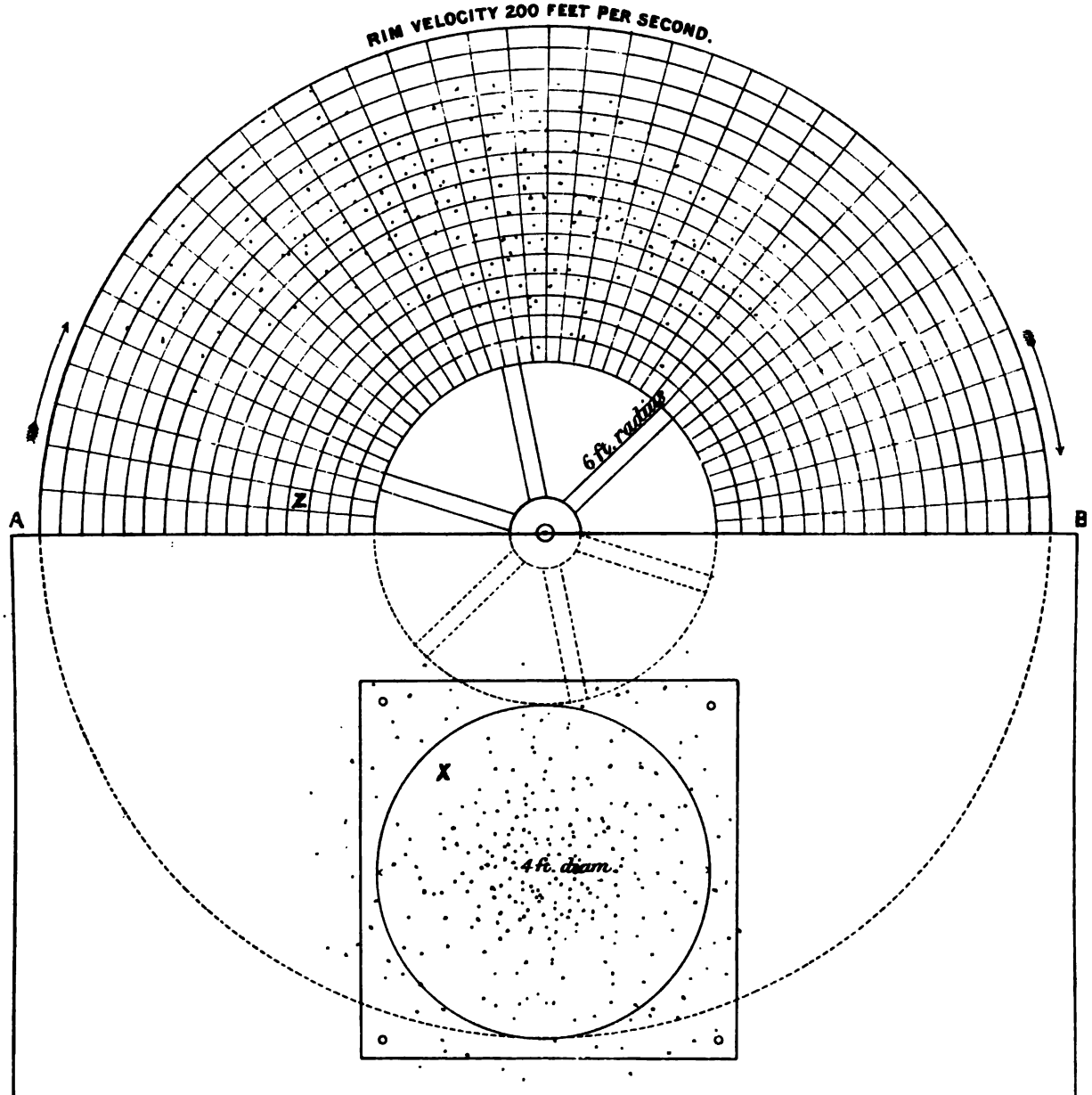
3. Where to take Velocity for calculating the Body of the Charge.—Again, many experiments have convinced me that the fairest point for this purpose is the *centre of the first 25 per cent. of the pattern next after the fastest pellets*. There is a regularity in results obtained at this point which I have not found at any other; and not only so, but this point gives the velocity of the first 30 per

* The perpendicular lines drawn by Mr. Griffith passed through pellet-marks included in his calculation, but these pellet-marks are sometimes obscured by the engraver having substituted dotted lines instead of the plain lines on the photograph. It is desirable to mention this, in order to explain an apparent anomaly, where reference is made to "the last ten pellets," but only eight are readily noticeable, the other two being concealed by the dotted lines in the illustration on page 55.—Ed.

cent. of the pattern—a very fair estimate of its killing value. So I draw a line horizontally through the point where 25 per cent. of the pattern is counted after the first 5 per cent. are ruled off, and measure the distance from the centre of this group to the base line. In the marked photograph this is the centre between lines B and C, and the measurements show a difference of ·0062sec., or a loss of 42ft. on the mean velocity for this range. This in my table I call *System A*.

Or, as in the table under *System B*, instead of taking the line at 25 per cent., it may be placed where 45 per cent. of the pattern is counted after ruling off the first 5 per cent.—thus making it mark the centre of the entire pattern; and the centre of this group, measured to the base line, will give the velocity of one-half the pattern. In the marked photograph this is the centre between lines B and D, and measures ·0077sec., or a loss of 52ft. velocity.

Or, again, the measurement may be made at the half-pattern line



A.B.C.D. *Screen covering the lower half of the target & perforated with a 4 ft diam. aperture & arranged so as to coincide with the target behind. Over this aperture is strained a thin sheet of paper.*

DRAWING OF REVOLVING TARGET & ARRANGEMENTS.

itself, as under *System C*. This gives the average velocity for the whole charge: and in the photograph it is shown by taking the distance between line D and the base line; and this measures ·0130sec., or a loss in velocity of 86ft.

For comparison sake I have added to the table under *System D* the measurement of the *last pellets* of the pattern, which I find by experiment to average 3 per cent. of the charge; and this is shown on the marked photograph by measuring from the centre of the last group, between lines E and F, to the base line—amounting to ·0425sec., or a loss in velocity of 231ft.

It will be noticed, on looking at the tables of velocities and the respective losses, that the percentage loss for the middle ranges runs fairly constant: but in the case of the shortest range (10 yards), and also in that of the longest range (60 yards), the percentages frequently differ. I explain this by supposing that, in the 10 yards range, the pellets which fly fastest are the first to break away from the mass, and thus lose much more velocity between 10 and 20 yards than does the bulk of the charge; and that, in the case of the 60 yards range, the target aperture did not collect the *lowest* and *slowest* pellets of the whole charge, and that by just so much are my patterns too short for showing the pellets that were actually last in a 60 yards range. In this case, however—as it is the effective pellets in a charge that we really wish to consider—those that fall to the ground before reaching 60 yards need not enter into our calculations as regards velocity.

Using this revolving target as a guide, I can regulate my velocity targets to register any succeeding arrival of the charge, from the first small flight of pellets to the general mass; and my custom has been for years to take the first 30 per cent. of the pattern (5 + 25) as representing the main body of the charge. R. W. S. GRIFFITH.

Resuming our remarks, it may be said, in general terms, that the spread of the charge from a cylinder gun at a given range is pretty nearly the same as that of a full choke-bore at a one-half longer distance. Thus, on referring to the illustrations, it will be seen that, when the same cartridge is used (containing 3drs. powder and 1¼oz. No. 6 shot), the pattern of the cylinder gun at 20 yards closely resembles that of the choke-bore at 30 yards—each having only two pellets outside the 4ft. circle, though the choke has a few more pellets within the lesser circle, of 30in. diameter.

In the next comparison, the cylinder pattern at 30 yards strikes the eye as not quite so close as that of the choke-bore at 40 yards; and the greater amount of scattering is evidenced by 14 per cent. of the charge being outside the 4ft. circle when the cylinder gun is used at 30 yards, whereas only 2 per cent. is outside with the choke-bore at 40 yards.

With the next increase of range, it is found that there are one-third more pellets outside the 4ft. circle with the cylinder gun at 40 yards, than with the choke-bore at 50 yards; while the pellets within the smaller circle are 160 with choke and 130 with cylinder at the respective distances just mentioned.

With the cylinder at 50 yards, the scattering attains very large dimensions, nearly one-half the entire charge being outside the 4ft. circle.

And at 60 yards the cylinder has nearly as many pellets outside the larger circle as the choke-bore has within it; the numbers being—choke-bore, 195 within the 4ft. circle, and 109 without; cylinder 118 within the 4ft. circle, and 186 without.

The area of the 30in. circle is equal to 707 square inches, and that of the 4ft. circle equals 1810 sq. in. Taking the respective patterns at the different distances, we find that, in the smaller circle, there is, at 30 yards, one pellet for every 2¼ sq. in. with the choke-bore, or one to 4 sq. in. with the cylinder gun; at 40 yards, 3 sq. in. to each pellet with the choke and 5½ sq. in. with the cylinder; at 50 yards, 4½ sq. in. with the choke and 9¼ sq. in. with the cylinder; and at 60 yards, 7 sq. in. with the choke and 11½ with the cylinder.

In the larger circle, of 4ft. diameter, the relative proportions are as follows: At 40 yards, 6 sq. in. to each pellet with the choke-bore and nearly 8 sq. in. with the cylinder; at 50 yards, 7¼in. with the one as against 11 sq. in. with the other; and at 60 yards 9 sq. in. and 15 sq. in. respectively.

Consequently, for those who can make pretty sure of shooting within a 4ft. circle between 40 and 60 yards, the chances of hitting the game are about 3 to 2 in favour of the choke-bore, irrespective of the force of the blow, which will be heavier with the choke-bore, owing to the greater velocity of the pellets. Between 30 and 40 yards, the chances with the choke will be rather higher than above stated for those who can shoot within a 2½ft. circle. But when the shooting is most likely to occur between 20 and 30 yards, the greater spread of the shot from the cylinder gun is undoubtedly advantageous to those who are not very sure in their aim; and the pattern is quite close enough.

The following is a summary of the number of pellets on or off the target at the different ranges, the charge in every instance consisting of 304 pellets of No. 6 shot:

Gun and Charge.	20 yards.		30 yards.		40 yards.		50 yards.		60 yards.	
Choke-bore, with 3drs.:										
In 30in. circle	all		278	302	233	298	160	250	100	195
,, 30—48in. belt	0		24		65		90		95	
Outside 4ft. circle	0		2		6		54		109	
Choke-bore, with 3½drs.:										
In 30in. circle	297	304	259	299	199	288	135	243	93	185
,, 30—48in. belt	17		40		89		108		92	
Outside 4ft. circle	0		5		16		61		119	
Cylinder, with 3drs.:										
In 30in. circle	264	302	172	262	130	233	76	162	61	118
,, 30—48in. belt	38		90		103		86		57	
Outside 4ft. circle	2		42		71		142		186	

The observations in the last few paragraphs, relative to pattern and spread of the shot charge, are intended to apply to "pattern" in the ordinary sense, as shown on a stationary target, and represented in the circular photographs. These give what may be said to be "full-face" portraits of charges of shot, whereas the rectangular photographs give "side-views" of the same. These side-views, however, are not exact profile representations of the charge, because the slow pellets actually "tail off" to a much greater extent than is apparent on the face of the illustrations. The circles of barely 2in. diameter are proportionate representations of targets of 4ft. diameter, and, the elongated photographs being on the same scale, their 2in. width represents a 4ft. space on the moving target. But the length of these photographs does not represent a definite distance, in the same way that the width does; it corresponds with a definite interval of time, because the target revolves at a fixed rate of speed; but it does not correspond with the actual distance that one pellet follows after another, because their velocity is different from that of the target.

The speed at which the target revolves being uniformly 200ft. per second—whereas the shot may move at rates varying from two or three up to five or six times that velocity, according to the distance of the target from the muzzle of the gun—it is obvious that the space between the lagging and the faster pellets must exceed the distance depicted on the photograph in the same proportion as the speed of the shot exceeds the speed of the revolving target.

An estimate of the difference in this respect may be made by referring to the times hereafter recorded in Mr. Griffith's table. From the figures there given it will be seen that, with the cylinder gun, in a range of 40 yards, the first pellets struck the target in ·138sec. after the gun was fired, whereas the last batch in the same charge took ·187sec. to complete the distance—or more than one-third extra time. Consequently one part of the charge might kill a bird at 40 yards, while another portion may have traversed little more than 30 yards; or the fastest pellets might just miss the tail of the bird fired at, while the slowest of the pellets might kill another bird some feet in the rear.

Of course a bird would not be killed that lagged behind its fellow to the same extent as the one batch of pellets lagged behind the other, because the rate of speed is so different; but, supposing it to be requisite to shoot from three to six yards ahead of a bird (according to its velocity of flight) in order for the first portion of the charge to kill it, there would be no chance of its being hit by the last pellets unless the aim were one or two yards further in front; so, as it is best to choose the lesser of two evils, it is wiser to run the risk of aiming too far forward, rather than that of being behind; because, in the one case, if you are too much in front with the fast pellets, you may chance to kill with the slower ones, whereas, in the other case, if you are behind with the fast pellets you miss your bird altogether.

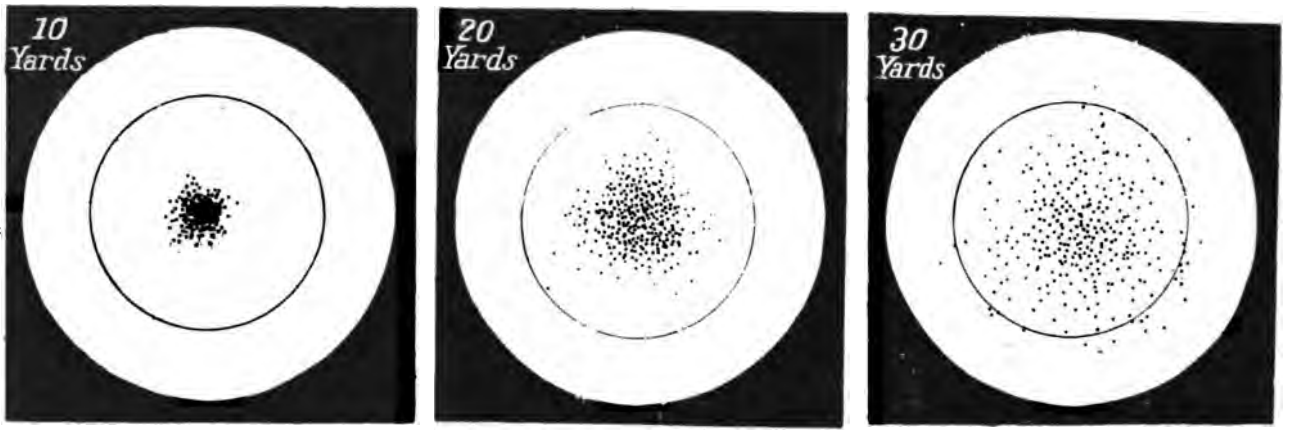
It should be borne in mind that these experiments were all carried out with carefully-loaded cartridges—as is evident when one looks at the even distribution of the pattern on the circular photographs. Therefore there are, under the best of circumstances, certain conditions, not hitherto generally understood, which tend to favour the escape of the game when so many pellets are flying around. And with cartridges loaded in a careless manner, or with defective wads, the shot would be scattered much more erratically, the loss of speed would be greater, and wide gaps would occur, allowing the birds to pass unscathed between the pellets. Indeed, with bad wads and uneven loading, the charge becomes so wildly scattered that a 4ft. target at 40 yards is not unfrequently missed by the majority of the pellets; while those which do strike the target are likely to have a very uneven distribution. What the width of the gaps may amount to under such circumstances may be conjectured on taking note of the distances which occur between the pellets in good patterns. The

[*Continued on page* 58.

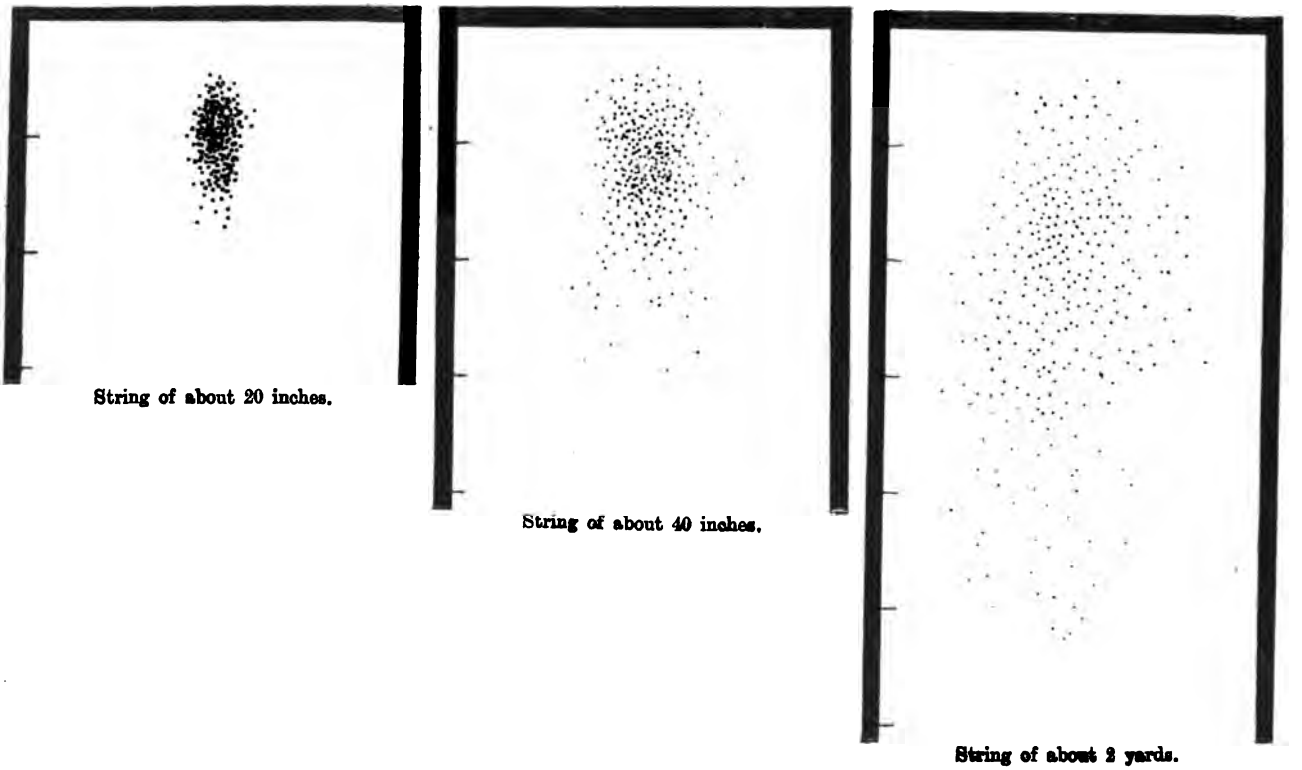
FIRST SERIES.

CHOKEBORE GUN, LOADED WITH 42 GRAINS OF SCHULTZE AND 1⅛OZ. OF NO. 6 SHOT.

PATTERNS ON FACE OF FIXED TARGET.



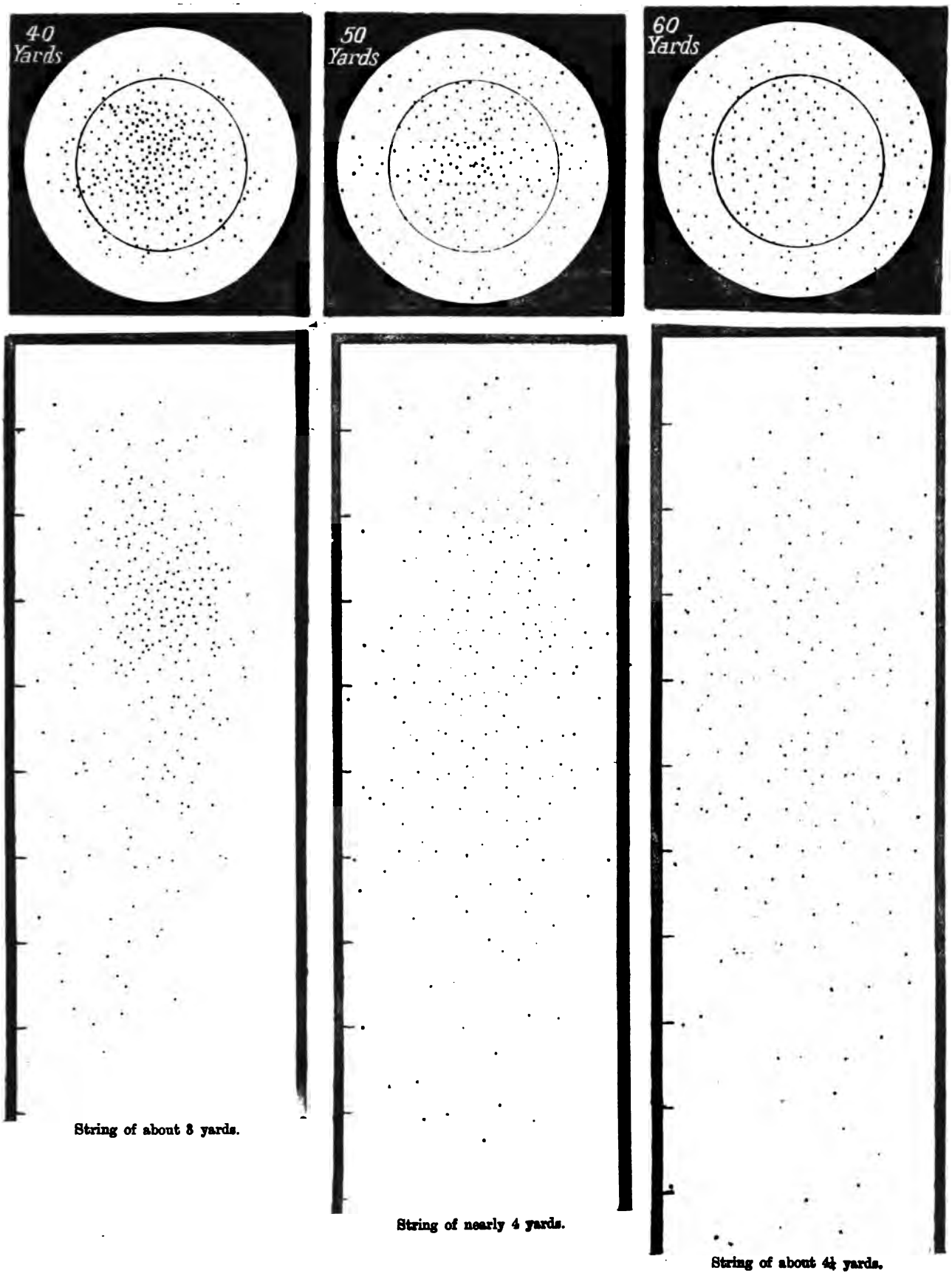
PATTERNS ON REVOLVING TARGET.



String of about 20 inches.

String of about 40 inches.

String of about 2 yards.



String of about 3 yards.

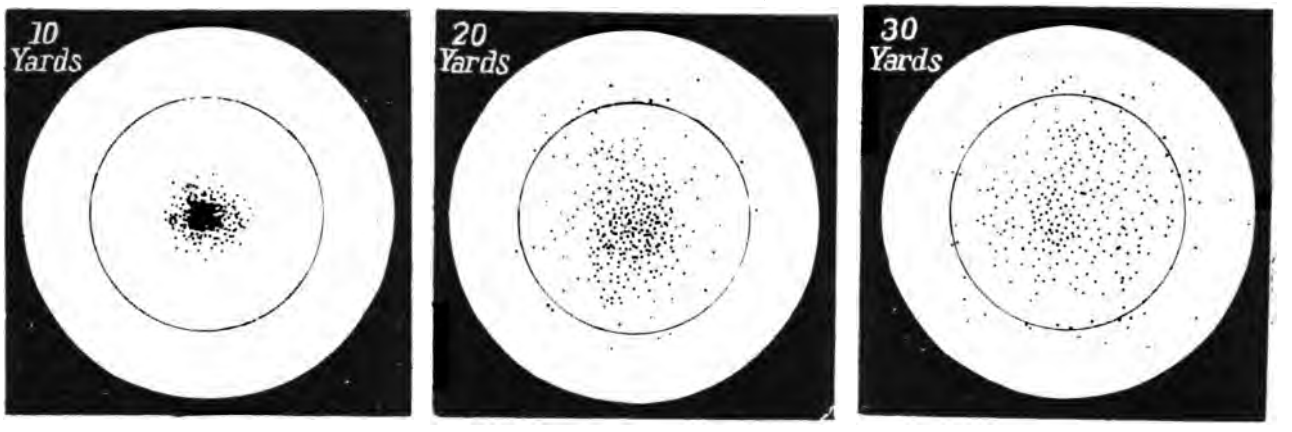
String of nearly 4 yards.

String of about 4½ yards.

SECOND SERIES.

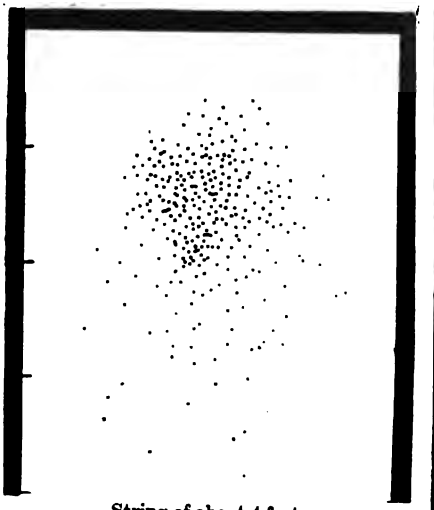
CHOKE-BORE GUN LOADED WITH 49 GRAINS OF SCHULTZE AND 1⅛OZ. OF NO. 6 SHOT.

PATTERNS ON FIXED TARGET.

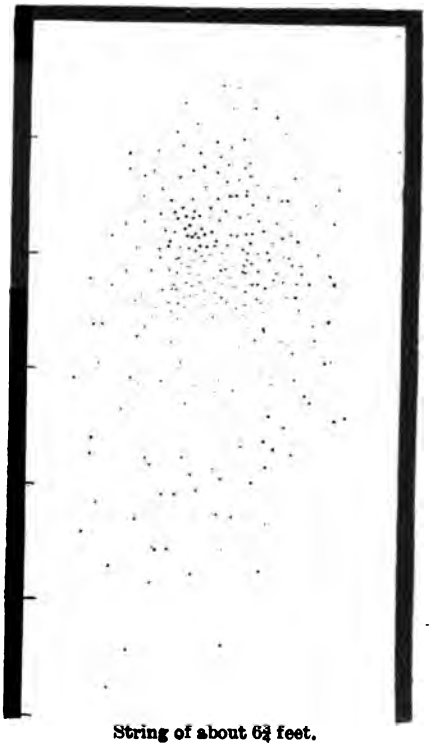


PATTERNS ON REVOLVING TARGET.

String of about 2½ feet.



String of about 4 feet.



String of about 6¾ feet.

String of about 8¼ yards.

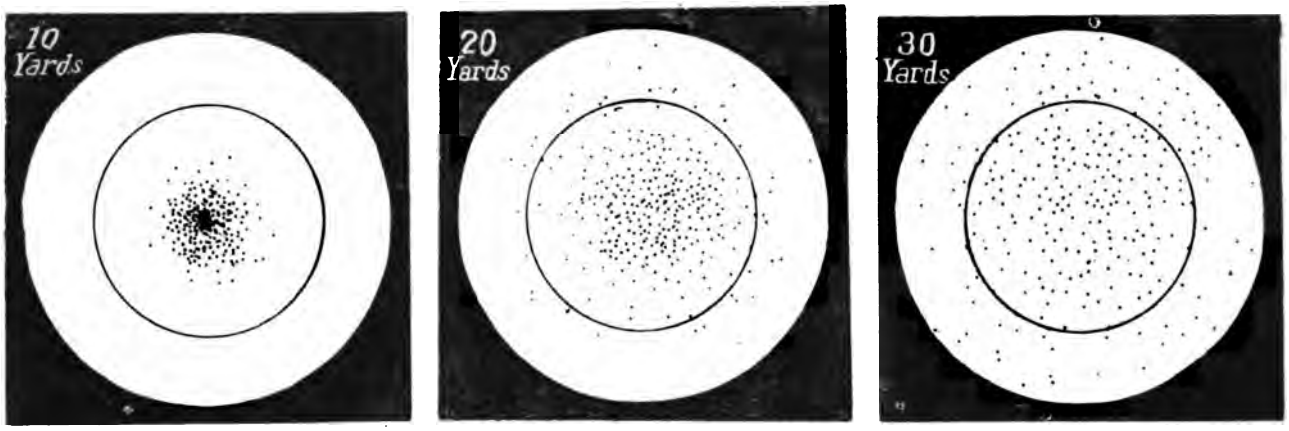
String of about 4½ yards.

String of nearly 4½ yards.

THIRD SERIES.

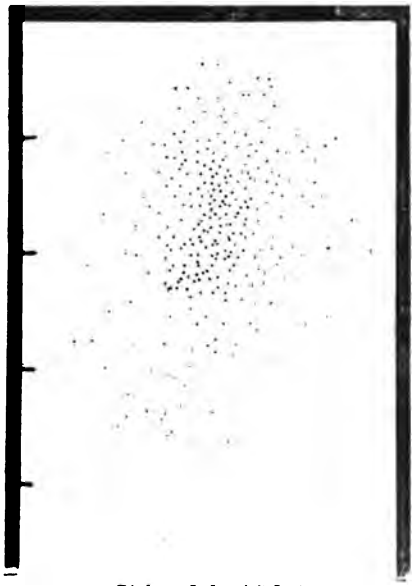
CYLINDER GUN LOADED WITH 42 GRAINS OF SCHULTZE AND 1⅛OZ. OF NO. 6 SHOT.

PATTERNS ON FIXED TARGET.

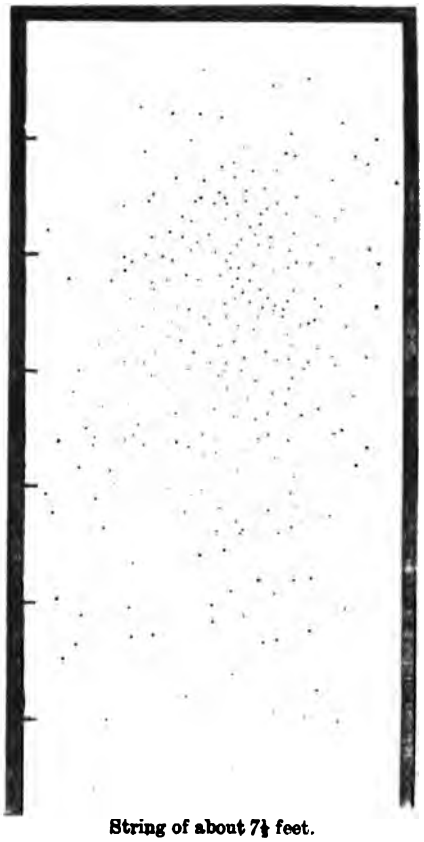


PATTERNS ON REVOLVING TARGET.

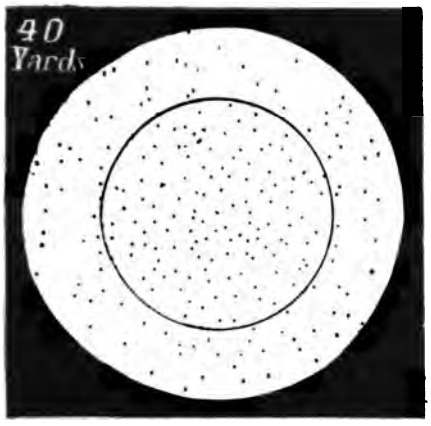
String of about 2½ feet.

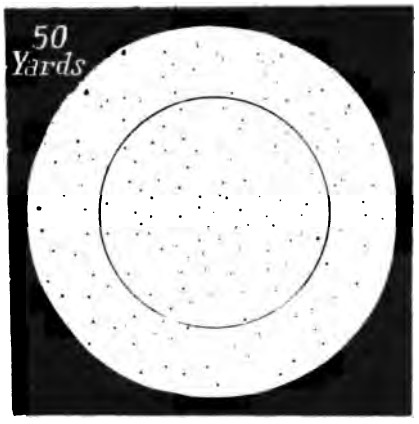


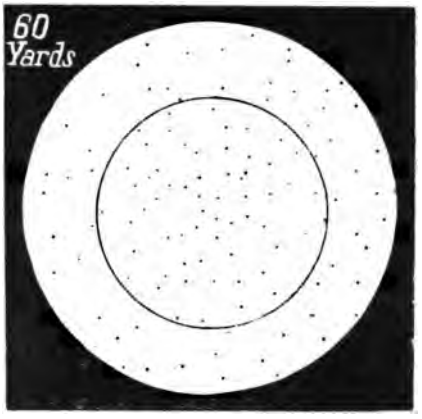
String of about 5 feet.



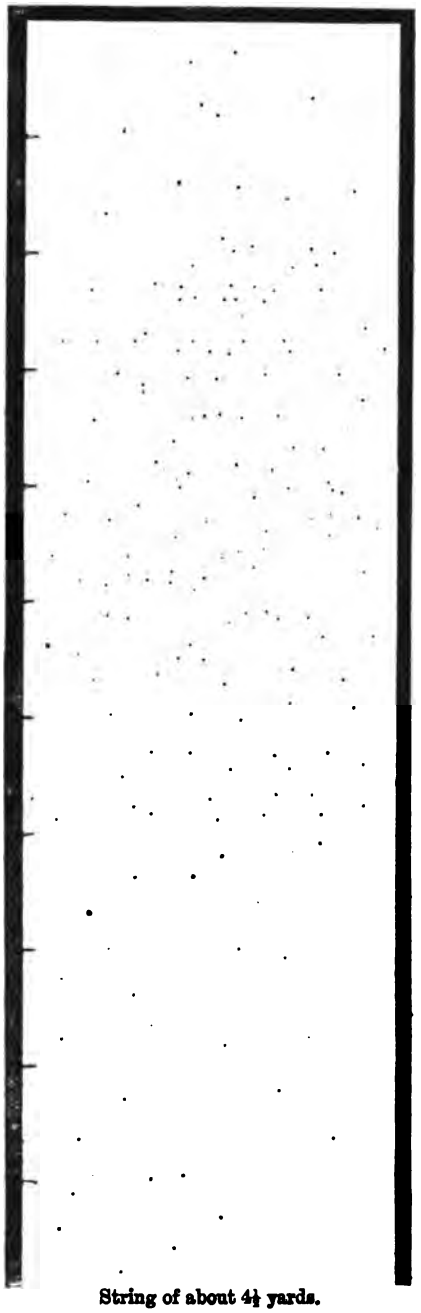
String of about 7½ feet.







String of about 4 yards.



String of about 4½ yards.

String of about 4¾ yards.

TABLES OF VELOCITIES CALCULATED FROM THE MOVING TARGET PATTERNS AS SHOWN ON PHOTOGRAPHS.

Gun and Load.	Range yards.	First cluster of pellets reach the target.		Measured by System A.				Measured by System B.			
		Chrono-graph velocity.	Equivalent time.	25% of pattern lag behind.	Total time for the range.	Equi-valent velocity.	Less velocity than the first pellets.	45% of pattern lag behind the 5%.	Total time for the range.	Equi-valent velocity.	Less velocity than the first pellets.
First Series.		Ft.-Sec.	Sec.	Sec.	Sec.	Ft.-Sec.		Sec.	Sec.	Ft.-Sec.	
CHOKEBORE, with 3drs. powder and 1⅛oz. No. 6.	10	1132	·0265	·0010	·0275	1091	41ft., or 3·6%	·0017	·0282	1063	69ft., or 6·1%
					·0304	*=987*			*·0308*	*=974*	
	20	1073	·0559	·0020	·0579	1036	37ft., or 3·3%	·0031	·0590	1017	56ft., or 5·2%
					·0379	*=792*			*·0385*	*=779*	
	30	976	·0923	·0035	·0958	939	37ft., or 3·8%	·0052	·0975	923	53ft., or 5·4%
					·0454	*=661*			*·0455*	*=660*	
	40	884	·1357	·0055	·1412	850	34ft., or 3·8%	·0073	·1490	839	45ft., or 5·1%
					·0536	*=560*			*·0546*	*=549*	
	50	802	·1871	·0077	·1948	770	32ft., or 3·9%	·0105	·1976	760	42ft., or 5·2%
					·0822	*=365*			*·0829*	*=362*	
	60	675	·2668	·0102	·2770	650	25ft., or 3·7%	·0137	·2905	642	33ft., or 4·9%
Second Series.	10	1209	·0248	·0012	·0260	1153	56ft., or 4·6%	·0020	·0268	1119	90ft., or 7·4%
CHOKEBORE, with 3½dr. powder and 1⅛oz. No. 6.					*·0296*	*=1013*			*·0288*	*=1042*	
	20	1124	·0534	·0022	·0556	1079	45ft., or 4·0%	·0032	·0556	1060	64ft., or 5·7%
					·0357	*=840*			*·0372*	*=806*	
	30	1031	·0873	·0040	·0913	986	45ft., or 4·4%	·0055	·0928	970	59ft., or 5·7%
This one is marked on photograph to show method of calculating.					*·0429*	*=699*			*·0429*	*=699*	
	40*	938	·1290	·0062	·1342	894	44ft., or 4·7%	·0077	·1357	884	54ft., or 5·8%
					·0508	*=598*			*·0507*	*=592*	
	50	855	·1754	·0090	·1844	814	41ft., or 4·8%	·0110	·1864	805	50ft., or 5·8%
					·0649	*=462*			*·0657*	*=457*	
	60	756	·2381	·0112	·2493	722	34ft., or 4·5%	·0140	·2521	714	42ft., or 5·5%
Third Series.	10	1128	·0266	·0015	·0281	1067	61ft., or 5·4%	·0027	·0293	1024	104ft., or 9·2%
CYLINDER, with 3drs. powder and 1⅛oz. No. 6.					*·0314*	*=955*			*·0312*	*=962*	
	20	1062	·0565	·0030	·0595	1008	54ft., or 5·1%	·0040	·0605	991	71ft., or 6·7%
					·0390	*=769*			*·0400*	*=750*	
	30	963	·0935	·0050	·0985	914	49ft., or 5·1%	·0070	·1005	895	68ft., or 7·1%
					·0475	*=632*			*·0472*	*=636*	
	40	870	·1380	·0080	·1460	823	47ft., or 5·4%	·0097	·1477	813	57ft., or 6·6%
					·0557	*=538*			*·0574*	*=523*	
	50	784	·1915	·0102	·2017	743	41ft., or 5·2%	·0136	·2951	731	53ft., or 6·7%
					·0803	*=374*			*·0794*	*=378*	
	60	667	·2700	·0120	·2820	638	29ft., or 4·4%	·0145	·2845	633	34ft., or 5·1%

System A consists in measuring a line across the first 5% of the charge, and a line across the next 25% of the pattern, and then measuring the distance from centre to centre of each space so marked.
System B as above as regards the first 5%, but the next line is drawn at the exact half-pattern, and then the distance from centre to centre of each space so marked is measured.

illustrations being, as already stated, only $\frac{1}{12}$ of the full scale, an eighth of an inch in the distance between two pellets is equivalent to three inches in reality; or half an inch would represent a foot.

In fact, there are many interesting little problems that may be worked out by those who will devote the necessary time to a careful examination of Mr. Griffith's photographic representation of the charges of shot, and a comparison of the figures in his table of results; and those who do so will find a great deal of information to repay them for the time they have devoted to the subject.

In these tables we have inserted, in *italic* figures, the respective times, and corresponding velocities, for every intermediate 10 yards, so that the velocity stated between 10 yards and 20 yards may be taken as representing the actual velocity at 15 yards; that intermediate between 20 and 30 yards would represent the speed of the shot at 25 yards; and so on. It will be observed that the velocities as measured by systems A and B are very close together, while those measured by systems C and D are much wider apart. We will therefore take the average of the A and B systems as representing the probable velocities at the respective distances, and we append thereto the energy or striking force per pellet at these ranges. This having been done, the results work out as follows:

Velocity of the Pellets at the Respective Ranges.

	20 yards.	30 yards.	40 yards.	50 yards.
Choke-bore with 3½drs.	925 ft.sec.	761 ft.sec.	647 ft.sec.	528 ft.sec.
„ with 3drs.	885 „	723 „	608 „	463 „
Cylinder with 3drs.	859 „	696 „	583 „	453 „

With these velocities, the amount of energy or striking-force in one pellet of No. 6 shot, at the above-mentioned ranges, would be as follows:

Energy of No. 6 Pellet at the Respective Ranges.

	20 yards.	30 yards.	40 yards.	50 yards.
Choke-bore with 3½drs.	49·2 ft. oz.	33·3 ft. oz.	24·1 ft. oz.	16·0 ft. oz.
„ with 3drs.	45·0 „	30·0 „	21·7 „	12·3 „
Cylinder, with 3drs.	43·4 „	27·8 „	19·6 „	11·8 „

It will be seen therefore, that the energy or killing-power of the pellets with the 3½ dr. charge, was undoubtedly higher than with 3 drs., as might be anticipated. But with the choked and cylinder barrels, used under exactly the same conditions, and with equal charges, the choke gave higher velocity, and consequently more killing-power; and this was shown to a greater extent at 40 yards than at shorter distances. Thus:

	20 yards.	30 yards.	40 yards.	50 yards.
	ft. oz.			
Cylinder	43·4	27·8	19·5	11·8
Choke	45.0, or + 6%	30·0, or + 8%	21·7, or + 11%	12·3, or + 4%

Beyond 40 yards, however, when the charges from both barrels became widely scattered, the choke did not retain its superiority to the same extent.

TABLES OF VELOCITIES CALCULATED FROM THE MOVING TARGET PATTERNS AS SHOWN ON PHOTOGRAPHS.

Gun and Load.	Range yards.	Measured by System C.				Measured by System D.			
		Mean velocity of the whole pattern lags behind the 5%.	Total time for the range.	Equivalent velocity.	Less velocity than the first pellets.	Last 10 pellets lag behind the first 5%.	Total time for the range.	Equivalent velocity.	Less velocity than the first pellets.
First Series.		Sec.	Sec.	Ft.-Sec.		Sec.	Sec.	Ft.-Sec.	
CHOKEBORE, with 3drs. powder and 1⅛oz. No. 6.	10	·0030	·0295	1017	115ft., or 10·2%	·0070	·0335	896	236ft., or 20·8%
	20	·0051	·0610 (·0315 = 952)	983	90ft., or 8·4%	·0145	·0704 (·0369 = 813)	852	221ft., or 20·6%
	30	·0088	·1011 (·0401 = 748)	890	86ft., or 8·8%	·0220	·1143 (·0439 = 684)	788	188ft., or 19·3%
	40	·0129	·1486 (·0475 = 632)	808	76ft., or 8·6%	·0360	·1717 (·0574 = 523)	699	185ft., or 20·9%
	50	·0174	·2045 (·0559 = 536)	733	69ft., or 8·6%	·0460	·2331 (·0614 = 489)	644	158ft., or 19·7%
	60	·0250	·2918 (·0873 = 344)	616	59ft., or 8·7%	·0540	·3208 (·0877 = 342)	561	114ft.. or 16·9%
Second Series.	10	·0033	·0281	1067	142ft., or 11·8%	·0090	·0338	888	321ft., or 26·5%
CHOKEBORE, with 3½drs. powder and 1⅛oz. No. 6.	20	·0058	·0592 (·0311 = 965)	1013	111ft., or 9·9%	·0180	·0714 (·0376 = 798)	841	283ft., or 25·2%
	30	·0090	·0963 (·0371 = 809)	935	96ft., or 9·3%	·0270	·1143 (·0429 = 699)	788	243ft., or 23·6%
* This one is marked on photograph to show method of calculating.	40*	·0130	·1410 (·0447 = 672)	851	87ft., or 9·3%	·0425	·1685 (·0542 = 564)	704	234ft., or 24·9%
	50	·0180	·1934 (·0524 = 573)	776	79ft., or 9·2%	·0500	·2254 (·0569 = 527)	665	190ft., or 22·2%
	60	·0256	·2637 (·0703 = 427)	683	73ft., or 9·6%	·0590	·2971 (·0717 = 418)	606	150ft., or 20·0%
Third Series.	10	·0050	·0316	949	179ft., or 15·9%	·0117	·0383	784	344ft., or 30·5%
CYLINDER, with 3drs. powder and 1⅛oz. No. 6.	20	·0076	·0641 (·0325 = 923)	936	126ft., or 11·9%	·0222	·0787 (·0404 = 742)	762	300ft., or 28·3%
	30	·0120	·1055 (·0414 = 724)	858	110ft., or 11·4%	·0340	·1275 (·0488 = 615)	706	257ft., or 26·7%
	40	·0160	·1540 (·0485 = 619)	779	91ft., or 10·4%	·0490	·1870 (·0595 = 504)	642	228ft., or 26·2%
	50	·0233	·2148 (·0608 = 494)	698	86ft., or 11·0%	·0570	·2485 (·0615 = 488)	603	181ft., or 23·1%
	60	·0260	·2960 (·0812 = 370)	606	59ft., or 8·8%	·0570	·3270 (·0785 = 382)	550	117ft., or 17·5%

System C is the same as System B as regards the two lines, but measurement is made from the centre of the first space to the second line. System D is the same as above as regards the first 5%. Then the last 3% of the pattern is ruled off, and the centre of this space is measured from the centre of the first 5%.

G.—T.

THE SPREAD OF SHOT OF DIFFERENT SIZES.

(*Field*, April 2, 1887; vol. 69, p. 451.)

SIR,—"No. 8" states in a recent letter that small shot spreads more than large. There is a widespread impression that large shot scatters more widely than small. I should be very much obliged if you would tell me which is the right doctrine. Hitherto I have used small shot, under the impression that it kept together better than large, and so was more killing in small-bore guns. If it spreads more than large shot, it would seem to be a mistake to use it.

A. B.

[We do not think that any absolute rule can be laid down, as so much depends upon the boring of the gun and the charge that is used. Generally speaking, we believe that the small sizes spread rather more than the large, but the same gun will behave differently with different sizes of shot and different charges of powder. Some years ago Mr Griffith carried out some experiments which bear on the above question. He fired charges of various sizes of shot through a series of screens fixed at 5, 10, and 15 yards from the muzzle of the gun, and measured the diameter of the pattern marked on each screen. The measurements, with 1oz. shot from No. 2 to No. 8, fired with 3drs. of powder, were as follows—the diameter of the pattern being given in inches:

	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
5 yards	8½	8	4	4	4½	4	4
10 ,, ...	7	6	6	6½	7	7	6½
15 ,, ...	10	9	10	11	11	12	11

The gun used was a moderately choked 12-bore, giving a pattern of about 150 with 1oz. of No. 6. The same gun was also tried with charges of 2½ drs. and 3½ drs. with three sizes of shot—the largest, smallest, and intermediate—under the same conditions as above stated, with the following results:

	No. 2.			No. 5			No. 8.		
	2½drs.	3drs.	3½drs.	2½drs.	3drs.	3½drs.	2½drs.	3drs.	3½drs.
5 yards ...	4	3½	5	4	4	5	4½	4	7
10 ,, ...	9	7	9	9	6½	9	10	6½	11
15 ,, ...	14	10	14	13	11	13	14	11	15

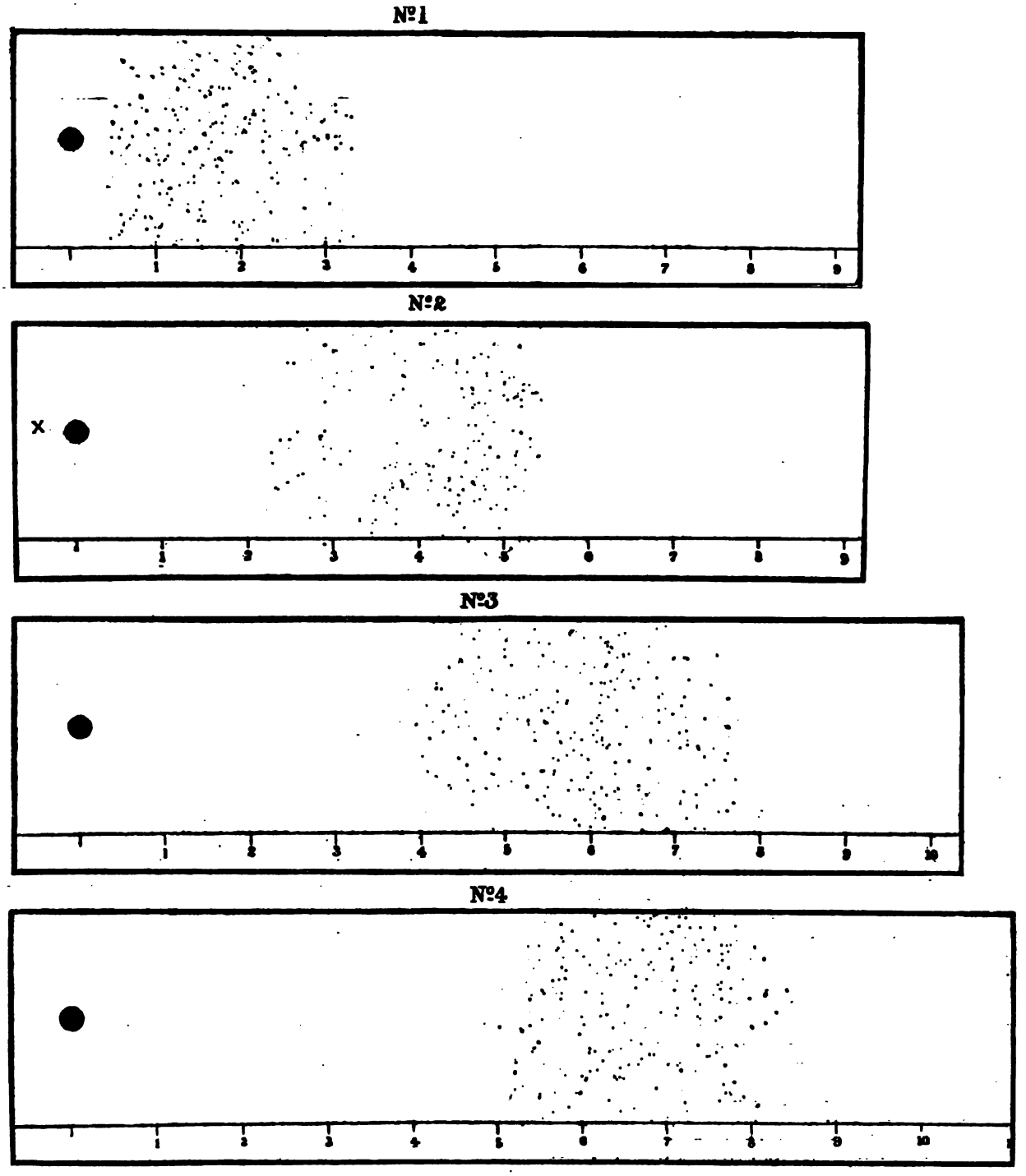
Here it will be seen that the spread with 3drs. was, as a rule, less than with either 2½drs. or 3½drs. But, as frequently has been pointed out in the *Field*, one must not expect exactly the same kind of results from using the same charges in other guns. In order to find out what will be the effect of using this size of shot, or that charge of powder, experiments should be made with your own gun; as, if you pin your faith upon the statement of what has been done with the gun of somebody else, you may be greatly misled in the result, although the statement itself may be perfectly true.—ED.]

SHOT-CHARGES FIRED AT MOVING TARGETS.

(*Field*, Sept. 20, 1890; Vol. 76, p. 459.)

SIR,—Having had an opportunity of trying some experiments with a shot gun at a moving target, I enclose you four photo-diagrams giving the results.

The target (a whitewashed plate of sheet iron, attached to the side of a railway vehicle) moved at right angles to the line of fire, from right to left, and the distance from gun to target at the moment of firing was 40 yards. The time occupied by the target travelling between two points, 58⅓ yards apart, (*i.e.*, 1-30th mile), was taken by stop watch, and the shot was fired when the target was midway between the two points, so that the mean speed of target at the time of firing was ascertained with sufficient exactness. The line across the



bottom edge of target is marked off in feet; the distance from this line to top edge of target is 30in. The bull's-eye to the left is the spot aimed at. The gun used was a Winchester repeater, 12-bore.

I was trying an experimental load of 70grs. black powder and 1oz. of No. 6. The load does not suit the gun, and the pattern, as such, is bad; but that does not affect the mean position of the charge on the target.

When firing, I got the gun on the mark a few yards before it arrived at the right place for firing, and kept it there until fired; so that the muzzle of the gun was moving with the mark at the moment of firing, *i.e.*, there was "swing" on the gun.

No. 1 TARGET (speed, 11·4 miles per hour, 16·75 feet per second).—Shot, 1ft. 9in. behind the mark.

No. 2 TARGET (speed, 22·8 miles per hour, 30·5 feet per second).—Shot, 4ft. 6in. behind (allowing 6 in. for error of aim, as shown by cross to left of mark).

No. 3 TARGET (speed, 28·25 miles per hour, 41·5 feet per second).—Shot, 6ft. (nearly) behind.

No. 4 TARGET (speed, 32 miles per hour, 47 feet per second).—Shot, 6ft. 9in. behind.

The mean velocity of the shot, as deduced from No. 3 and No. 4 targets—which, I believe, are accurate as to speed of target, and on which I know that the aim was good—would be about 846ft. per second.

I think that there is some indication of a lengthening out of the pattern on No. 3 and No. 4. This, of course, would become more marked at higher speed; but even at speeds of 40ft. to 50ft. per second the displacement due to movement of the target between the first and last pellets of the charge would be considerable. The striking velocity of the shot (70grs. black and 1oz.), as per table published in *The Field* of April 19, 1890, would be about 590ft. per second. This velocity, when the target was moving at thirty-two miles per hour or 47ft. per second (as in No. 4), would give a displacement of nearly 6in. between the first and last pellets, supposing that the charge were only 6ft. long when it reached the target, *i.e.*, if the leading pellets were 6ft. in advance of the rear pellets.

It is, I think, quite possible that a gun which would make an even pattern at a stationary target might, owing to displacement, make a patchy pattern at a moving target, or *vice versa*.

Although there is nothing very scientific, and possibly nothing new in the above, still the diagrams may interest some of the readers of *The Field*; they will, at any rate, serve to illustrate the necessity for aiming forward at cross shots. H. A. IVATT.

THE PATTERNS OF CHOKED AND UNCHOKED GUNS.

(*Field*, October 13, 1888; Vol. 72, p. 521.)

WHEN the choke-bore was a novelty, and began to attract considerable attention from lovers of the gun, many views were propounded as to the mode of action of the choke upon the charge of shot; but, although much was written with reference to curves which the pellets were supposed to describe during their flight, and other matters bearing more or less upon the subject, very little practical evidence was produced, as far as we are aware, to demonstrate the accuracy of any of the respective theories. And the books on the art of shooting which have since been published, whatever may be their merits in other respects, have not greatly enlarged the amount of available information upon this particular feature of the many-sided problems that are connected with the motion of projectiles. It is not surprising, therefore, that wishes are expressed, from time to time, that something should be done to throw a little more light upon the subject; and the latest suggestion of the kind has been received from a foreign correspondent, Major Thiel, who, in our impression of August 11, 1888, said that he had consulted some of the most recent books on gunnery without finding the information he sought, and consequently asked to be enlightened upon certain points. No one having responded to this appeal, we have been induced to carry out a few experiments; and, although we do not profess that they will afford complete and definite replies to the questions specially put, we lay them before our readers in the hope that they may be of interest, and add something to the facts that have previously been placed upon record.

We need hardly say that one great difficulty connected with investigations into the motion of shot charges, as they leave the muzzle of the gun, arises from the complications produced by the rush of gas that accompanies the exit of the mass of pellets, and by the body of compressed air that is driven out in advance of the shot and wads. Hence, if a wire is fastened across the muzzle of a gun, in order to obtain a chronographic record, the wire is apt to be broken by the condensed air before the charge itself has actually reached the end of the barrel; and thus the record will be more or less vitiated, according as the prematureness in breaking contact bears a large or small proportion to the whole time of the chronograph record. And, on the other hand, if a target is placed in close proximity to the muzzle of a gun, it is usually so much knocked about by the combined action of the projectiles and accompanying gases as to be rendered practically useless for comparison with other targets placed at greater distances.

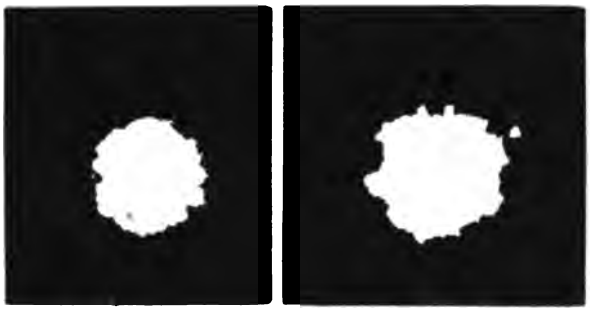
With the view of obviating the troublesome effects thus produced, a member of our staff proposed to fire charges of shot through a supplementary tube fixed some little distance in front of the muzzle of the gun; and he accordingly had a tapering tube made of gun-metal, bored out at one end to a diameter of 2in., but diminishing gradually to the size of an ordinary 12-bore at the opposite extremity, where it ended in a full choke of the usual character. This tube (which is 18in. in length) was fastened in the centre of a long horizontal support, with a fixed rest for the gun at one end, and a sliding frame for the targets at the other. When the muzzle of the gun was fixed at a distance of 30in. from the broad end of the tapering tube, it was found that, on the gun being fired, the entire shot-charge would enter the opening and pass through the tube. And it will be understood that, in its course, the charge would, on leaving the muzzle of the gun, first traverse the intervening space of 2½ft. in the open air (thereby getting clear of most of the powder gases), then the shot would enter the broad end of the supplementary tube, and finally, after passing through the tube and emerging from its choked muzzle, the pellets would act upon the target placed a short distance in front.

The targets were made of a thin kind of glazed cardboard (technically known by the name of "glazeboards"), backed up by wood (dry white pine) 1in. in thickness. This compound target was adopted after trying many kinds of material, metallic and otherwise; cards of different thicknesses, and plates of various kinds of metal, were burst and torn through in too irregular a fashion to be of any service whatever; but when the thin glazed card was backed up by a pine board, there was usually a tolerably clean perforation through the card, which was not interfered with by the subsequent tearing and splintering of the wood on the farther side of the board. With this apparatus the following experiments were made:

A target was fixed at a distance of 2in. from the muzzle of the taper tube, and the gun was then fired, the charge of shot piercing the target; a fresh target was then fixed at 4in. from the muzzle, and the gun again fired; and so on up to 12in., when the distance was increased to 18in. Beyond this distance the supplementary tube was dispensed with, the ordinary gun alone being used. After a series of targets had been obtained with the taper tube in its choked condition, the choke was bored out, and another series was taken, under similar conditions, with the cylinder boring. Of course several charges were fired at each distance, so as to ascertain that the results were of a practically uniform character. The ordinary charge of 42grs. of Schultze and 1⅛oz. of No. 6 shot was used throughout. The choke-bore employed was a single-barrelled gun of 12-gauge, made by Messrs. Cogswell and Harrison, and giving a pattern of about 220 in a 30in. circle at 40 yards. The single barrel was chosen as being more convenient for experimental purposes, in fixing it on the horizontal support; and all the charges fired into the supplementary tube (both before and after the choke was removed) were fired from this gun, so that the conditions might be the same with both kinds of boring. After the supplementary tube was dispensed with (at distances beyond 18in. from the muzzle) the single-barrel was still used for the choke-bore experiments, and the ordinary cylinder barrel of another gun was used for the experiments with the cylinder boring.

The experiments thus made go to prove, what one might naturally anticipate, that the action of the inclined surface of the choke causes the outer portion of the charge to converge towards the centre. The evidence of this fact, however, is more marked than one could expect, as, at a distance of 2in. from the muzzle, the charge from the choke is found to be one-sixteenth of an inch less in diameter than the muzzle from which it issued; and the difference of effect between the chokebore and the cylinder is further demonstrated by the cardboard facing of the target being always sound (except as regards the ordinary shot perforations) when the cylinder was fired, whereas with the choke, when the target was either at 2in. or 4in. from the muzzle, the cardboard was so shattered by the combined effect of the shot and the residue of gas and compressed air, that the card was rendered useless as a record. In the following figures are given copies, taken by photographic process, from the targets used with the choke and cylinder. All the illustrations are copied directly from the cardboard facing of the target except in the case of the chokebore at 2in. from the muzzle. The cylinder target at that distance is copied from the card, but that of the choke had to be taken from the wood backing, as the card was too much damaged to be available; and we may add

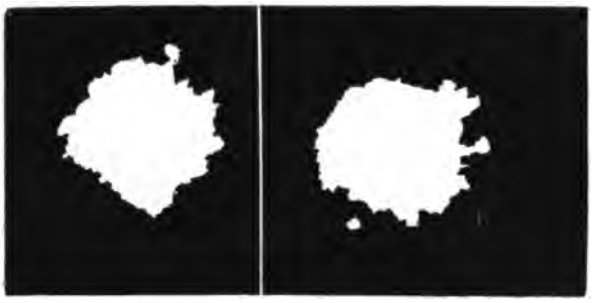
that the edge of the hole in the wood is bruised, as though struck by a wad, the perforation made by the shot being less in size than the wad. We tried to push a 12-bore wad through the holes in the wood of both the 2in. and 4in. chokebore targets, but without success, although the wads from the gun must necessarily have been squeezed through the perforation. In both the 2in. and the 4in. choke-



CHOKE AT 2 INCHES. CYLINDER AT 2 INCHES.

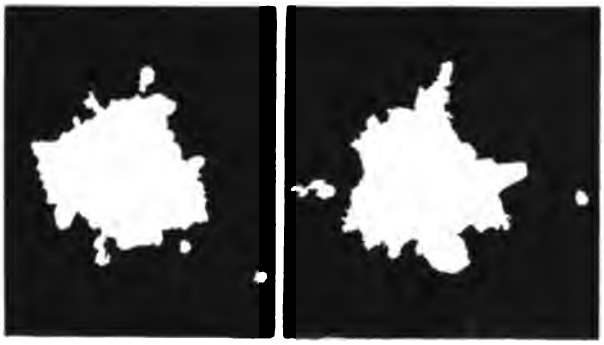
bore targets a 20-bore wad fits tightly into the hole; but in the latter this is to some extent due to the wood having become rather jagged during perforation by the shot-charge.

We do not propose to give representations of the targets at every distance, as the variations, from step to step, are not always sufficiently marked to be readily noticeable. We therefore next show the targets at 6in. from the muzzle, where the outer pellets of the charge have opened out a little, the diameter of the perforation in the target being about eight-tenths of an inch.



CHOKE AT 6 INCHES. CYLINDER AT 6 INCHES.

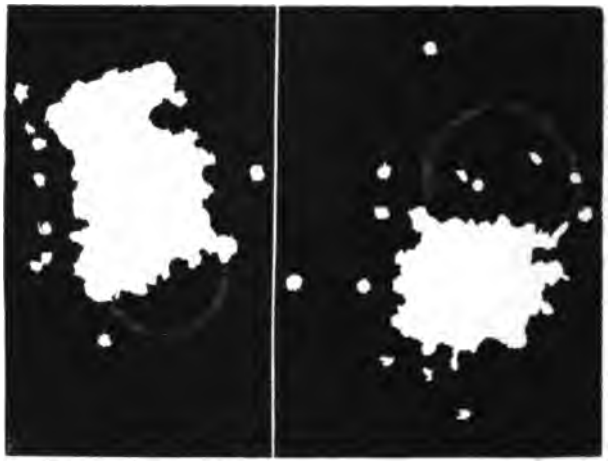
Beyond a slight increase in the size of the perforations, there is



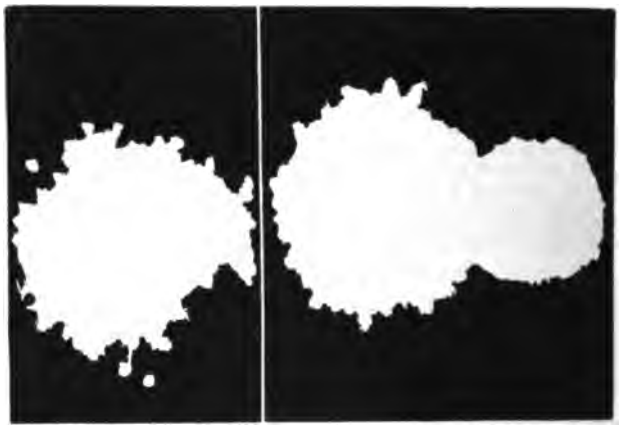
CHOKE AT 12 INCHES. CYLINDER AT 12 INCHES.

nothing material to notice in the targets at 8in. and 10in. from the muzzle; but as the distance is increased, irregularities arise, through pellets being thrown off from the main body of the mass, as shown in the 12in. targets.

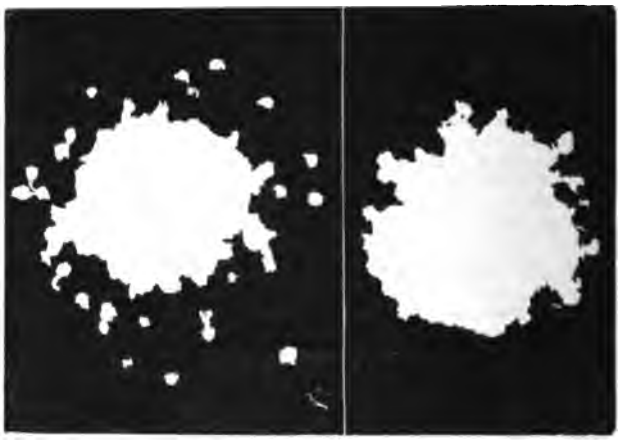
And sometimes there is a further complication arising from the wads separating more or less from the shot, and striking the cardboard separately, as shown by the bruises indicated by the faintly-marked segments of a circle seen on the 18in. targets, next given.



CHOKE AT 18 INCHES. CYLINDER AT 18 INCHES.



CHOKE AT 24 INCHES. CYLINDER AT 24 INCHES.

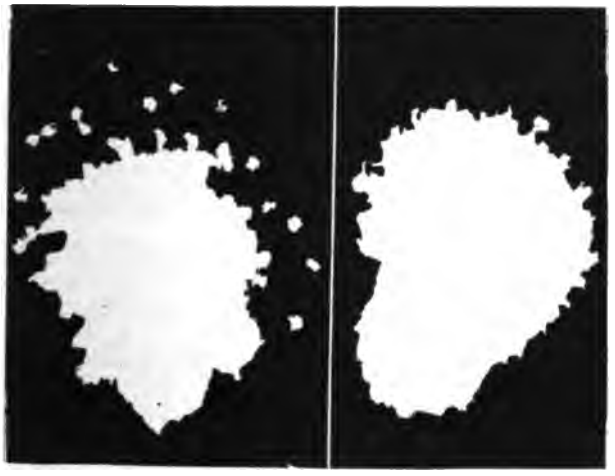


CHOKE AT 30 INCHES. CYLINDER AT 30 INCHES.

Here, in the 18in. cylinder target, it would appear that the bruise must have been made by the felt wad after the pellets had passed through the card; for, if a wad were backed up by the force of the

shot, the probability is that the wad would have been completely driven through, as shown in the cylinder target at 24 inches.

As previously stated, at distances beyond 18in. the supplementary



CHOKE AT 3 FEET. CYLINDER AT 3 FEET.

tube was dispensed with. and the ordinary gun alone was used. Targets were pierced at 24in., 30in., 3ft., and afterwards at one-yard intervals up to 18 yards. As will be seen opposite, in the 30in. target,

CHOKE-BORE AT 6 FEET.

the pellets outside the main body of the choke-charge present a marked feature; but, of course, the compactness of the nucleus cannot be seen, owing to the target being cut away so completely.

In the 3ft. targets, in the previous column, the wads have again interfered with the regularity of pattern, as is quite obvious with the cylinder, and probably also occurred with the choke-bore.

At distances beyond one yard the pattern begins to spread considerably, especially with the cylinder; but the charge from the choke has a nucleus from which pellets detach themselves gradually. This was distinctly shown when firing at a distance of 6 feet, about thirty pellets becoming detached and spreading themselves over a circle of 3in. diameter, but the body of the charge went through like a bullet. The pellets of the cylinder, however, are still so close together as to cut out the cardboard completely, as shown in the following illustration.

CYLINDER AT 6 FEET.

At 4 yards the extreme spread from both barrels was about 6in., but the choke had a large nucleus, with the rest of the pellets rather sparsely scattered, whereas the cylinder pattern was more evenly distributed over the entire space. At this distance, the wads struck the targets several inches clear of the extreme pellets of the shot. At 6 yards, the cylinder pattern had spread so much that it would cover about the size of one of these pages, nearly all the pellets being clearly apart; whereas the chokebore retained a distinct nucleus, which gradually diminished at longer distances, but did not disappear till the range was increased to 18 yards; and at that point the chokebore pattern showed almost exactly the same spread as the cylinder at 6 yards. Indeed, although the one pattern was taken at three times the distance of the other, the two were scarcely distinguishable for spread and regularity.

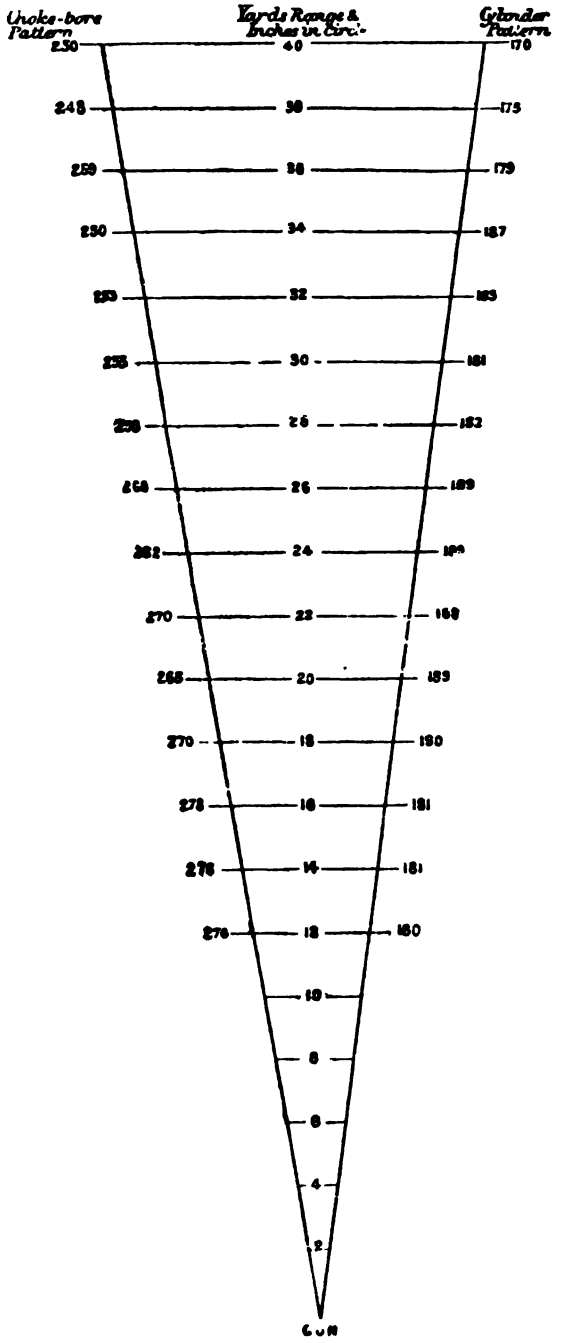
P.—T.

PATTERNS FROM CHOKED AND UNCHOKED GUNS.

(*Field*, Nov. 17, 1888; Vol. 72, p. 731.)

In our impression of Oct. 13, 1888, we gave a number of engravings representing patterns made by choke-bore and cylinder guns; and, in a brief notice, in continuation of the subject, in our issue of the following week, we stated that we would, in accordance with a suggestion that had been made, take some patterns with the same guns at longer ranges. In carrying out these experiments, we found that a mere enumeration of the measurements representing the spread of pattern at different distances was not at all a satisfactory method of recording the results, as a few straggling pellets might greatly enlarge the extreme measurements in some instances,

although there might be little difference in the general character of the pattern. Accordingly we adopted instead a method of taking the number of pellets placed by the chokebore and cylinder barrels in a given circle for a stated distance, and increasing the diameter of the circle uniformly with every increase of range. Thus, beginning at



the distance of 12 yards, the number of pellets in a 12in. circle were taken; at 14 yards the circle was increased in diameter to 14in.; and at every successive two yards, up to a range of 40 yards, patterns were taken with an enlargement of the circle by two inches at each stage. And in order that the regularity of the patterns might not be in any way interfered with by inaccuracy o aim, "selected patterns" were made, or, in other words, the circles were described around the centre of the pattern on the respective sheets after the targets had been shot at.

The chokebore patterns were taken, as in the previous experiments, with a 12-bore gun by Messrs. Cogswell and Harrison; and the cylinder patterns with a 12-bore gun by Messrs. Woodward and Son. The latter gun is bored in the old-fashioned way, being a little opened at the breech, and then nearly cylindrical to within 6in. of the muzzle, where it is slightly relieved. Both guns give good regular shooting; but they were not selected as in any way extraordinary representatives of their class, and were merely taken as being conveniently at hand at the time they were wanted. The ordinary charge of 42grs. of Schultze and 1¼oz. of No. 6 chilled shot was used throughout; and the pattern stated is the average of six shots at each distance.

The foregoing diagram will give a graphic representation of the regular enlargement in the dimensions of the targets as the length of the range was increased; while the number of pellets in the choke-bore patterns are indicated by the numbers on the left-hand side, and those made by the cylinder barrel are shown by the corresponding score on the right hand. We do not give any numbers for less distances than 12 yards, because the chokebore targets at 10 yards were so much out about that it was impossible to say how many pellets had passed through some of the open spaces; and the number counted was consequently too low to be accurate.

The average pattern made by the choke-bore, for the whole of the fifteen distances, was 262, or 86 per cent. of the entire charge of 304 pellets. The average with the cylinder was 184, or 60 per cent. of the entire charge. It will be observed that, by this regular increase of circle with distance, there is not a very wide departure from the average, either with the chokebore or the cylinder. But an examination of the figures shows some points of difference between the two series. There are certain irregularities —as may always be expected when a number of rounds are fired with shot charges—and therefore a direct step-by-step comparison cannot well be made; but by dividing them into three groups of five ranges each (say 10 to 20 yards, 20 to 30 yards, and 30 to 40 yards), we find that the chokebore is above the average in the first group, near about the average in the second group, and below it in the third; whereas the cylinder is almost exactly the average in the first group, above it in the second, and below it in the third. The comparison is more readily made in per-centages than in the actual numbers: and we therefore give a table, showing the nearest per-centage without resorting to fractions:

PROPORTION OF BARREL TO WHOLE CHARGE.

Range.	Diameter of Circle.	Choke Pattern.	Cylinder Pattern.
12 yards	12in.	91 per cent.	59 per cent.
14 ,,	14in.	91 ,,	60 ,,
16 ,,	16in.	91 ,,	60 ,,
18 ,,	18in.	89 ,,	62 ,,
20 ,,	20in.	87 ,,	60 ,,
22 ,,	22in.	89 ,,	62 ,,
24 ,,	24in.	86 ,,	64 ,,
26 ,,	26in.	87 ,,	62 ,,
28 ,,	28in.	85 ,,	62 ,,
30 ,,	30in.	84 ,,	60 ,,
32 ,,	32in.	83 ,,	60 ,,
34 ,,	34in.	82 ,,	62 ,,
36 ,,	36in.	85 ,,	59 ,,
38 ,,	38in.	82 ,,	58 ,,
40 ,,	40in.	82 ,,	56 ,,
	Average	86 ,,	60 ,,

If we summarise the groups, the results appear about as follows:

Ranges.	Choke-bore.	Cylinder.
10 to 20 yards	4% above average	Very near the average.
20 to 30 ,,	Barely the average	3% above average.
30 to 40 ,,	4% below average	3% below average.

Looking at these figures, it would seem—so far as one may infer from experiments with only one barrel of each method of boring—that the pellets from both guns keep pretty nearly to straight lines, and so the spread of the shot does not depart very widely from a conical form throughout the whole length of range.

Beyond 40 yards it was hardly practicable to carry on the investigation of the "conical spread" as shown above, owing to the large size of the targets required, and therefore we reverted

to the ordinary 30in. circle, with which we commenced at 20 yards and proceeded by steps of five yards each up to 60 yards; but, in order to give a further indication of the spread of the charge, a second circle was also drawn with a diameter of 40in. The records of choke and cylinder patterns thus ascertained are as follows:

PELLETS IN CIRCLES OF THIRTY AND FORTY INCHES.

Range.	Thirty Inch Circle.		Forty Inch Circle.	
	Choke.	Cylinder.	Choke.	Cylinder.
20 yards	all	255	all	284
25 ,,	235	184	all	244
30 ,,	265	140	292	229
35 ,,	257	130	290	195
40 ,,	218	117	248	169
45 ,,	140	84	203	125
50 ,,	115	78	169	116
55 ,,	93	65	130	96
60 ,,	80	56	120	92

By way of supplement to the above, we give another table showing the number of square inches of space there would be to every pellet, supposing the pellets were evenly distributed throughout the ordinary 30in. circle, and in the belt from 30 to 40 inches.

AREA PER PELLET OF CHOKE AND CYLINDER PATTERN.

Range.	Thirty Inch Circle.		Belt from 30 to 40in.	
	Choke.	Cylinder.	Choke.	Cylinder.
20 yards	2·3 sq. in.	2·8 sq. in.	—	19·0 sq. in.
25 ,,	2·5 ,,	3·5 ,,	29·0 sq. in.	9·2 ,,
30 ,,	2·7 ,,	5·0 ,,	20·4 ,,	6·2 ,,
35 ,,	2·8 ,,	5·4 ,,	16·7 ,,	8·4 ,,
40 ,,	3·2 ,,	6·0 ,,	18·3 ,,	10·6 ,,
45 ,,	5·5 ,,	8·4 ,,	8·7 ,,	13·4 ,,
50 ,,	6·2 ,,	9·1 ,,	10·2 ,,	14·4 ,,
55 ,,	7·6 ,,	10·9 ,,	14·9 ,,	17·7 ,,
60 ,,	8·8 ,,	12·6 ,,	13·8 ,,	15·3 ,,

The above figures serve to demonstrate the reason—so frequently stated in words—why unchoked barrels are very often preferred to those that are choked, viz., that the charge from the latter does not spread widely enough, at short ranges, to provide a remedy for inaccuracy of aim. For many men a 30in. spread is insufficient—they require 40in. at least. And it will be seen how differently the belt between 30in. and 40in. is covered by the pellets from the choke and the cylinder barrels at distances under 40 yards. At 45 yards and upwards, this belt is covered by pellets from the chokebore to just about the same extent as is produced by the unchoked barrel at 10 yards less distance. Indeed, with the cylinder, the pellets are thickest in this 10in. addition to the target when the range is 30 yards. These figures, however, only represent the patterns of one chokebore and one unchoked gun; and with other guns of each kind there may be more or less variation.

Trial of a True Cylinder Barrel.

We now come to the results obtained from the barrel bored to a true cylinder, except as regards the chamber and cone. The chamber was of the ordinary size for a 12-bore paper cartridge 2½in. long, the next quarter of an inch was occupied by the cone, and the remainder of the barrel (27¼in.) was bored to ·729in. diameter from cone to muzzle. The result of the shooting was that the number of pellets put upon the target by the true cylinder was practically the same as by Woodward's gun, viz., 119 by the former and 117 by the latter. But the pattern from the true cylinder was very patchy—so much so, indeed, that it would not be passed by any gunmaker; whereas that of Woodward's gun had a very regular spread. Six rounds were fired from each gun at 40 yards with 42grs. Schultze and 1⅛oz. of No. 6 shot. The results as regards pattern (30in. circle), record on the force-gauge, velocity by chronograph, and penetration in Messrs. Cogswell and Harrison's card-rack (by one and by three pellets), gave the following averages:

	Pattern.	Force.	Velocity.	Card Penetration. By three pellets.	By one pellet.
Chokebore	218	2·18	846 ft.-sec.	22½	24½
Cylinder (Woodward)	117	2·12	821 ,,	22½	24
True cylinder	119	2·16	840 ,,	21½	23

It will be observed that the choke-bore, besides placing a hundred more pellets in the 30in. circle, came out first in the records of the force-gauge, the chronograph, and the card-rack. The Woodward cylinder came next as regards penetration through the cards, though not so high as the true cylinder in the records by chronograph and force-gauge—a result due, in all probability, to the patchy shooting of the true cylinder, which might cause the effects to vary through a fast batch of pellets producing the record on one implement, and a slower batch operating on another. The recoil from all three barrels was exactly the same.

Having now, in accordance with request, carried out a few experiments with a barrel bored to a true cylinder, we may state that we by no means regard it as a representative of the ordinary shot guns made for the use of British sportsmen at any period between the days of Colonel Hawker and the present time. Indeed, the name of "cylinder," as characteristic of any special mode of boring, is quite a modern innovation. Not much more than a dozen years have elapsed since it came into use for this distinctive purpose. In the report of the *Field* Gun Trial of 1875 we do not find the word "cylinder" used, either in the Editorial report, or in that of the Committee—one of the members of which was our old friend "20,000 Shots." Chokebores were frequently mentioned, but barrels of the other description were commonly alluded to as "guns bored on the old system." For some little time after this trial there seemed to be no generally accepted title for the "guns bored on the old system." Some persons called them "smooth-bores," in order to distinguish them from "chokebores;" but this was felt to be an unsuitable term, because barrels of both kinds are smooth, and the name of smoooth-bore was already in general use in contradistinction to the rifled barrel. Eventually, however, "cylinder" was adopted as a less objectionable expression, though not a strictly correct representation of facts. In the conditions for the *Field* Gun Trial of 1878, the words "chokebore" and "cylinder" were regularly used; and among the conditions agreed to was the following with respect to cylinders: "No cylinder gun to have the internal diameter of its barrel larger than that of the muzzle, and the barrel not to be examined for more than 15in. down." The chokebores were to give a pattern of at least 170, and the cylinders at least 120, "with the powder of their respective enterers." But with other powders and other charges than those for which the respective guns were regulated there were considerable differences in the patterns made by the same guns; and, as some discussion frequently goes on relative to the patterns given by unchoked guns, it may be of interest to see what were the patterns made by the cylinders in the 1878 trial. As the object here is merely to show how patterns from the same guns vary when the conditions are changed, we shall not specify the names of the makers either of the guns or the powders, but shall merely indicate the six guns by Nos. 1 to 6, and the powders by the letters A to F.

	A.	B.	C.	D.	E.	F.	Mean.
No. 1 gun	129	128	126	122	135	138	= 130
No. 2 ,,	127	139	132	125	129	120	= 129
No. 3 ,,	122	125	123	135	135	125	= 128
No. 4 ,,	116	116	132	130	132	132	= 127
No. 5 ,,	119	111	128	103	103	102	= 111
No. 6 ,,	100	110	111	105	129	116	= 111

Mean average of six cylinder guns (900 rounds) 122

Every gun was tried six times, with 25 rounds in each series, or 150 rounds per gun. The charge of shot used was always 1⅛oz. of No. 6; but the competitors were at liberty to vary the charge of powder, and some used 3drs., others 3⅛drs., and others 3¼drs. It will be seen that the highest average for 25 rounds was 138, and the lowest 100; and the mean average of 900 rounds was 122. The corresponding average with the chokebore patterns was 190. P.—T.

SHOT VELOCITIES AT VARIOUS RANGES.

(*Field*, Dec. 4, 1886; Vol. 68, p. 837).

The following tables, showing the velocities of pellets of ten different sizes, at twelve ranges, varying from 5 yards up to 60 yards, with half a dozen different charges, represent the results obtained by firing more than two thousand experimental shots, in each of which the speed of flight of the pellets has been ascertained by means of the Boulengé chronograph. This vast amount of patient investigation has been carried out by Mr. R. W. S. Griffith, the manager of the Schultze Gunpowder Company's works, whose crusher-gauge apparatus we recently had the pleasure of describing (see page 29); and as Mr. Griffith leaves as little as possible to chance influences, by carrying out his experiments personally, and loading every cartridge himself, in order to ensure uniformity, these records may be relied

on as being as near to absolute accuracy as can well be attained by ordinary mortals. It will doubtless be remembered by many of our readers that we published, some years ago,* the results of a valuable series of experiments by the same gentleman, in which he recorded the pattern, as affected by different modes of loading, the striking force, recoil, and velocity exhibited by different charges of powder, both black and Schultze, and with various sizes of shot; but then the range was uniform, viz., 40 yards, and the velocities consequently gave no information for any other distance.

On the present occasion the powder used was Schultze only; but in order that the reader may see how little difference there was between the results obtained from black powder and Schultze in 1879, and how little variation of velocity exists in the Schultze records of 1886 as compared with those of seven years previous, we extract from our former pages the particulars with respect to two sizes of shot most generally used (No. 5 and No. 6) and put the figures of 1879 in juxtaposition with those that are to be found in the 40 yards records that appear in the new series of tables printed below—that is to say, in all instances where the charges used were identical in the two series of experiments. That being done we find the results as here given:

MEAN VELOCITIES OF SHOT IN RANGE OF 40 YARDS.

No. 6.	BLACK POWDER (C. & H. No. 4). ft. per sec.	OLD SCHULTZE (1879). ft. per sec.	NEW SCHULTZE (1886). ft. per sec.
2½drs. and 1oz.	759	781	776
3drs. and 1oz.	860	858	862
,, ,, 1½oz.	827	848	850
3½drs. and 1½oz.	909	915	894
,, ,, 1¼oz.	852	863	858
No. 5.			
2½drs. and 1oz.	816	817	792
3drs. and 1oz.	874	883	879
,, ,, 1½oz.	868	888	875
3½drs. and 1½oz.	899	912	907
,, ,, 1¼oz.	873	891	880

Although we have here dated the new Schultze as 1886, the two thousand experimental shots were, in fact, commenced in 1885 and completed in the next year. In the majority of cases three shots were fired with each charge at each distance; but when two successive shots gave exactly similar results, recourse was not had to a third. The gun used was a 12-bore C.-F., choked, giving an average pattern of 210 at 40 yards with 1½oz. of No. 6 shot and 3drs. of powder; one barrel was used throughout. The shot used counted to the ounce the following numbers of pellets respectively:

No. 1	94	No. 5	218	No. 8	448
,, 2	116	,, 6	270	,, 9	585
,, 3	139	,, 7	340	,, 10	860
,, 4	174				

In these experiments, the first few straggling pellets were not registered—the main body of the charge being the portion of which the velocity was taken; and the results obtained are shown in the following tables. The charges of powder are stated, as is the common practice, in drams; but, as the powder used was Schultze, the actual weight was, of course, the equivalent in grains, as stated between parentheses.

POWDER, 2½ DRS. (=35 GRS.); SHOT, 1 OZ.

Size of Shot.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.	45 yds.	50 yds.	55 yds.	60 yds.
No. 1...	1039	1022	1001	979	951	929	904	880	856	829	802	780
,, 2...	1034	1008	999	968	932	895	874	852	833	810	791	768
,, 3...	1020	999	980	954	927	896	861	824	798	776	760	742
,, 4...	1008	986	970	943	913	875	842	808	788	765	741	715
,, 5...	996	975	953	924	896	850	831	792	771	744	710	684
,, 6...	990	963	941	905	863	829	804	776	752	722	690	651
,, 7...	976	957	936	896	859	825	794	764	724	680	637	592
,, 8...	964	940	918	882	844	801	783	752	712	660	608	530
,, 9...	944	925	906	874	839	800	763	731	684	621	549	458
,, 10...	922	892	872	841	802	760	703	670	622	551	465	370

* The *Field*, June 14 and July 26, 1879; and reprinted in Vol. I. of "The Modern Sportsman's Gun and Rifle," pp. 39-46 and 346-352.

POWDER, 3 DRS. (=42 GRS.); SHOT, 1 OZ.

Size of Shot.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.	45 yds.	50 yds.	55 yds.	60 yds.
No. 1...	1185	1168	1150	1120	1076	1039	992	939	919	880	852	831
,, 2...	1178	1160	1139	1109	1060	1016	970	920	882	856	831	804
,, 3...	1168	1146	1120	1094	1051	999	956	906	876	846	810	779
,, 4...	1162	1137	1117	1081	1040	982	940	892	855	822	794	758
,, 5...	1160	1133	1106	1066	1021	969	922	879	840	801	764	729
,, 6...	1154	1130	1100	1061	1012	950	904	862	826	770	730	694
,, 7...	1147	1122	1101	1056	1004	951	900	846	796	740	690	631
,, 8...	1136	1116	1092	1038	978	928	866	820	782	730	665	590
,, 9...	1123	1101	1080	1031	961	914	839	790	749	685	603	520
,, 10...	1120	1094	1071	1029	959	891	809	751	704	630	559	440

POWDER, 3 DRS. (=42 GRS.); SHOT, 1¼OZ.

Size of Shot.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.	45 yds.	50 yds.	55 yds.	60 yds.
No. 1...	1169	1140	1126	1089	1054	1006	962	935	914	891	861	825
,, 2...	1160	1128	1110	1080	1041	982	950	918	881	856	820	790
,, 3...	1153	1118	1091	1064	1033	973	935	899	867	837	798	745
,, 4...	1134	1106	1088	1064	1020	964	925	887	849	808	759	706
,, 5...	1127	1034	1070	1047	1014	970	914	875	835	790	741	672
,, 6...	1119	1091	1063	1035	999	942	890	850	808	769	717	652
,, 7...	1091	1069	1042	1008	964	919	866	820	780	737	686	617
,, 8...	1083	1056	1026	981	935	885	835	786	739	689	626	556
,, 9...	1080	1050	1006	957	906	861	815	750	683	614	535	450
,, 10...	1076	1041	999	941	886	831	775	710	540	465	480	375

POWDER, 3½ DRS. (=49 GRS.); SHOT, 1⅛ OZ.

Size of Shot.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.	45 yds.	50 yds.	55 yds.	60 yds.
No. 1...	1220	1198	1175	1143	1103	1060	1012	966	938	914	890	876
,, 2...	1209	1187	1160	1126	1087	1045	1002	955	930	901	878	848
,, 3...	1200	1179	1145	1109	1972	1032	950	940	906	870	841	819
,, 4...	1193	1170	1136	1100	1056	1016	972	924	890	857	820	789
,, 5...	1182	1164	1126	1088	1045	1002	960	907	875	838	799	757
,, 6...	1175	1153	1120	1079	1032	986	940	894	861	825	780	723
,, 7...	1163	1141	1109	1061	1014	968	925	880	832	783	736	686
,, 8...	1149	1126	1098	1057	1010	962	912	856	808	756	704	647
,, 9...	1136	1107	1071	1026	980	930	876	830	774	714	649	581
,, 10...	1128	1096	1060	1012	965	892	830	781	711	630	550	460

POWDER, 3½ DRS. (= 49 GRS.); SHOT, 1¼ OZ.

Size of Shot.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.	45 yds.	50 yds.	55 yds.	60 yds.
No. 1...	1172	1151	1130	1111	1073	1029	989	949	908	867	835	799
,, 2...	1163	1143	1121	1100	1064	1020	980	931	891	856	818	778
,, 3...	1151	1134	1114	1090	1058	1012	960	915	870	829	790	749
,, 4...	1139	1120	1099	1074	1040	998	952	900	851	806	761	719
,, 5...	1130	1111	1088	1058	1026	979	931	880	834	790	741	689
,, 6...	1121	1100	1081	1050	1015	970	912	858	810	762	714	663
,, 7...	1110	1089	1067	1038	1000	946	888	836	787	737	685	630
,, 8...	1097	1075	1056	1021	980	937	876	815	765	713	658	590
,, 9...	1082	1058	1035	1001	961	910	851	791	736	659	598	535
,, 10...	1066	1041	1017	980	940	896	834	760	706	620	540	446

POWDER, 4 DRS. (= 58 GRS.); SHOT, 1¼ OZ.

Size of Shot.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.	45 yds.	50 yds.	55 yds.	60 yds.
No. 1...	1239	1221	1205	1181	1144	1106	1066	1022	976	936	909	863
,, 2...	1232	1216	1201	1171	1133	1092	1050	1008	961	921	883	843
,, 3...	1224	1204	1189	1156	1117	1078	1029	988	948	906	864	820
,, 4...	1216	1197	1180	1149	1109	1065	1013	956	910	869	830	792
,, 5...	1207	1190	1171	1134	1094	1051	994	932	892	853	810	764
,, 6...	1199	1177	1159	1122	1082	1034	977	907	850	816	774	734
,, 7...	1186	1161	1141	1099	1050	998	941	879	834	790	746	701
,, 8...	1162	1150	1128	1090	1036	978	920	858	802	750	704	662
,, 9...	1156	1129	1104	1068	1018	955	894	836	766	709	651	590
,, 10...	1145	1115	1090	1045	987	927	864	792	720	642	551	495

It will doubtless also interest many of our readers to know the amount of time which elapses between the fall of the hammer and the departure of the shot from the barrel. Mr Griffith has had very great experience in this class of experiment, as, for years past, every batch of Schultze powder has been tested in this way, to ascertain whether there is any tendency to hang fire, and, if such should be found to be the case, means are taken to remedy it.

The gun used for this purpose is the same as previously mentioned, a 12-bore, C.-F., choked. Using the standard charge of 3drs. powder and 1⅛oz. shot, with ordinary cartridge-case and cap, the time taken by chronograph, from the hammer falling to the shot reaching the muzzle of the gun, averaged ·0077 of a second with black powder (C. & H. No. 4); and with Schultze powder the average was ·0096 of a second. With 12-bore pin-fire cases the times are slightly less than those previously stated, owing, no doubt, to there being no brass dome between cap and powder to obstruct the flash. With large, strong cases, such as are used in the Belgian cases, the time was reduced with the black to ·0070, and with Schultze to ·0080 of a second. With basket powder, the time was shorter than with No. 4, being only ·0064 of a second; and with No. 6 it was longer, being ·0090 of a second.

With larger bores than 12-gauge, and also with larger charges in the 12-bore gun, the times are, as a rule, slightly longer than stated above. With smaller bores than 12, the times are slightly less, unless the gun is heavily choked.

When the time taken exceeds ·08 of a second, it is distinguished as a perceptible hang-fire, on the gun being fired from the shoulder. And when the time taken exceeds ·06 of a second, a "click" is heard between the pulling of the trigger and the report of the discharge.

We believe that most of these facts will be new to our readers as well as to ourselves; and we cannot but thank Mr. Griffith very warmly for the large amount of information which he has enabled us to make public.

VELOCITY OF BIRDS AND SHOT.

(*Field*, Dec. 11, 1886; Vol. 68, p. 854.)

SEVERAL correspondents have very politely invited me to express my views upon a subject which has been undergoing discussion in the *Field*, with respect to the speed of game birds, aiming forward, and the swing of the gun. May I, without discourtesy, say that the subject is one which I have not much inclination to discuss? I cannot pretend to add to the practical information that has already been given, or to make definite that which is at present very vague. I have no positive knowledge of the velocity of flight of the various game birds, but believe it is often greatly exaggerated; for I have known sportsmen assert that birds were "going at the rate of 100 miles an hour." My own impression is that they seldom fly at half that speed. However, be their speed whatever it may, your gun must be thrown sufficiently forward to compensate for it, or you will stand little chance of bagging your game. And, where the sportsman is confident in his own estimate of the speed of flight of birds, and is of a calculating turn of mind, an admirable opportunity is now presented of satisfying himself as to the compensation he ought to allow, seeing that Mr. Griffith's valuable tables of shot velocities (republished opposite) afford such reliable data to work upon. Thus, supposing the rate of flight to be taken at 40, 50, or 60 miles an hour, he has only to remember that a mile an hour is almost exactly equivalent to 1½ft. per second, and he thus has a ready means of comparison with the tables of velocity. These show, for example, that, with an ordinary sporting charge (3drs. and 1⅛oz.), the mean velocity of No. 5 or No. 6 shot is, in a range of 35 yards, about 900ft. a second, or at the rate of 600 miles an hour; and so, on comparing this 600 miles with the speed of the bird's flight, it will be found that the shot moves ten times at fast as a bird going 60 miles an hour; twelve times as fast as one that flies 50 miles an hour, and fifteen times as fast as one which goes 40 miles an hour. Consequently they would fly about 2½ yards, 3 yards, and 3½ yards respectively, while the shot is travelling 35 yards at the rate given above.

But while I am stating this, I cannot but remember what was said to me some years ago by a well-known authority on the game of whist. We were talking on the relative abilities of some of the best whist players of the day, and my friend, speaking of another, said: "So-and-so plays whist decidedly better than I do. *Give me time*, and I believe I could show sounder reasons than he could for the best line of play; but I cannot pretend to rival him in quickness of decision; and it is the faculty of seeing at once what ought to be done, and promptly acting upon that insight, that makes the best player."

So, it seems to me, it is with the shooter; the same faculty which wins the game in the one case, bags the game in the other. There is many a man who (*give him time*) will have a very sound perception of what to do with his gun, but he is apt to find that the bird will not wait for his meditations, and that his conclusions are not perfectly arrived at until after he has "scored a miss"—when his perceptions become remarkably clear. Among shooters, as among poets, there are those who are "born," rather than "made;" they may not acquire their skill without long practice and keen observation of cause and effect, but the special aptitude for doing the right thing on the spur of the moment is innate rather than acquired; and, where this faculty is deficient, no amount of experience will enable the shooter to pitch his gun exactly where it should be, under all conditions of pace, distance, and angle of flight. There are many men, no doubt, who swing their guns in the direction of crossing birds, and satisfactorily account for a very large proportion of their cartridges; but I cannot coincide with those who think that the swing itself has any material effect on the direction of the shot—except so far as it may cause the muzzle of the gun to be pointed in advance of the bird. The lateral motion imparted to the shot by the swing of the barrel would not *increase* as it approached the bird; in the absence of any deterrent effect, the tendency would be for the shot to retain the same speed and direction that it had when leaving the muzzle of the gun. Hence, if the gun were kept "dead on" a bird crossing at 40 yards distance, and the length of the gun (stock included) were, in round numbers, 40 inches, the muzzle would be swung an inch for every yard flown by the bird; or, supposing the bird were going at the rate of 50 miles an hour, the swing motion of the muzzle would only amount to about a mile and a half an hour. It is the mile and a half pace, not the 50 miles, that would put on "side" motion to the shot; and consequently, supposing that the bird flew 3 yards while the shot was traversing 40 yards, the swing motion alone would carry the charge but 3 inches in the same direction as the bird was flying; therefore the bird would be 8ft. 9in. in advance of the centre of the charge, or about 7ft. beyond its spread. Hence I cannot but consider that the real effect of swing, when put into successful operation, lies (as suggested by another correspondent a few weeks ago) in the muzzle of the gun being jerked some little distance in advance of the bird; and, as each inch of such advance in the muzzle corresponds with about a yard at the 40 yards radius, unanticipated results may arise from comparatively slight and unobserved movements. Furthermore, is it not possible that the different statements made by sportsmen as to how far they shoot in advance of flying game, may be due in some degree to their different perception of measurements of space between distant objects? Do they all take into consideration the effect of perspective? Let a stick, a yard long, be placed at a distance of 40 or 50 yards, in such a position that it comes between the eye and the sky, without any object near at hand that would afford a definite means of comparison; will that stick appear to be a yard in length? And, when the sportsman shoots at birds in the air, and sees them at a distance which he would say was two or three yards apart, he knows perfectly well that the birds would look much larger if they were close at hand, but does he always consider that they would likewise appear to be much wider apart?

My remarks upon the above subject have extended to greater length than I originally intended, as I purposed chiefly to comment upon Mr. Griffith's tables of velocities. This gentleman's labours, however, both past and present, will afford information tending to show why sportsmen may fail to kill their birds in crossing shots without suspecting a probable cause of failure. But first I will quote a few lines from the article on "Gunmaking" in Vol. II. of the "Encyclopædia Britannica" (1880), wherein the author, Colonel E. Maitland, R.A., says:

> Supposing the charge to retain an average velocity, on reaching the object fired at, of 300 feet per second, and the leading pellets to have gained 10 feet on the hindmost ones, so that the charge is distributed over a length of 10 feet, a period of time of one-thirtieth of a second will elapse between the blows of the first and the last pellet. If the object be stationary, this interval will be almost imperceptible, and the pattern made on the target by the impact of the shot will exhibit no trace of it. *But if the object be a bird flying across at the rate of 60 feet per second (about 40 miles an hour), it will traverse a space of 2 feet in the interval, and so will not receive the charge at all in the manner shown on the target.*

The concluding lines (which I have *italicised*) are very pertinent to the subject above alluded to; but there are facts on record even stronger than the hypothetical case put by Colonel Maitland. In the *Field* of June 14, 1879, Mr. Griffith described some experiments he had carried out, among which he had ascertained by chronograph the difference in velocity of the fast and slow pellets of ordinary charges fired from a 12-bore cylinder gun. In a 40 yards range, the fast pellets had a mean velocity of about 870 feet and the slow pellets of 730 feet per second, or a difference of about 140 feet per second; so that, when the fast pellets had completed the distance of 40 yards, the slow ones had only traversed between 33 and 34 yards, and the

charge of shot was consequently distributed over a length of about 20 feet, or double the space mentioned by Colonel Maitland. It is not surprising, with so disorganised a mass of pellets, that birds are missed by the sportsman, and that target records show the average amount of striking force to be comparatively low. Thus, a choke-bore gun was fired by Mr. Griffith with cartridges loaded exactly the same as those he used for the cylinder, and the chronograph showed that the velocity of the pellets from the choke-bore differed but little from the fastest of those of the cylinder, but the force-gauge record showed that the average striking force from the choke-bore was 15 per cent. higher than the average from the cylinder. Such was the result of the pellets being better kept together.

The importance of keeping the charge of shot in a concentrated mass for a considerable distance is greater than many sportsmen seem to realise. There are some who look upon special wads and exactitude in loading as mere "fads" that can easily be dispensed with; and others will not go to the trouble and expense. "Our forefathers," they say, "never required such fidd'e-faddles, and why should we?" But our forefathers never obtained the results that are now expected from guns bought at less than half the price which they used to pay. However, if people are content to use wads which allow the powder-gases to mingle with the shot charge, and to scatter the pellets abroad as soon as they are out of the barrel, it concerns themselves alone. The main purpose of these remarks is simply to explain how far the latest investigations tend to confirm views, long since put forward, with respect to the loss of killing power likely to ensue from a scattering of the shot.

The velocity of the loose pellets propelled from shot guns is a much more complex question to investigate than the speed of bullets, whether elongated or spherical, because the action of one projectile has alone to be considered in the latter case, whereas the simultaneous discharge of hundreds of small shot necessarily interferes with the individual action of the respective pellets, and the motion of each must consequently be modified by the presence of its companions. About seven or eight years ago I wrote several letters to the *Field* upon this subject, with the view of calling attention to some of the probable effects resulting from this companionship, owing to its influence on the velocity of the pellets after they have left the gun, and to its thereby affecting their striking force at the target, or their killing power when they hit game. The well-known fact that when a charge "balls," or when it is fired in a wire cartridge or other contrivance that temporarily concentrates the charge, the shot travels farther and strikes harder than when the pellets are freely scattered, is in itself sufficient to show that the rate of speed does not depend upon the propelling force of the powder alone. When two barrels of the same gun are known to give different results with cartridges that are loaded exactly alike, it is naturally attributed to a difference in the boring; the one barrel may be choked, and therefore shoots closer and harder than the other that is not choked. This choking does not impart greater propelling force to the powder, nor give the shot a higher muzzle velocity; it simply produces in the charge a kind of systematic balling, which, by concentrating the mass of pellets over a longer distance, enables them to retain more of their original velocity than the correspondiug charge fired from the unchoked barrel. And a reason for the scattered pellets losing more speed than the compact mass is readily seen when one considers that a solid ball of 12 to the pound would make 360 pellets of No. 6 shot (270 per oz.), and that these 360 pellets, when flying apart, would offer to the resistance of the atmosphere more than seven times the amount of surface presented by the 12-bore ball which equals them in weight.

In illustration of my arguments, in 1879, I gave some figures intended to afford an idea of the loss of velocity of pellets of No. 6 shot, flying loose, as compared with the retardation of a solid ball of the same weight as the shot charge. I based my calculations upon tables contained in Professor Bashforth's well-known treatise on "The Motion of Projectiles," upon the supposition that the charge of shot moved some yards through the air before the mass of pellets got broken up sufficiently to encounter the full resistance of the atmosphere. This method was very crude, as it simply regarded the shot charge as a solid ball for a given number of yards, and as isolated pellets for the rest of the range, without any of the gradations which necessarily occur in passing from the compact to the scattered condition; and it need hardly be said that Professor Bashforth's tables were never intended to apply to charges of small shot in fowling-pieces any more than to charges of grape shot in cannon.

The tables of velocities supplied by Mr Griffith, and published in the last issue (page 66), now afford materials for comparison such as I have for the last seven years been desirous of possessing, but scarcely expected ever to be able to obtain. Having got them, I soon set to work to ascertain how far the actual results fitted in with the theoretical notions. The method was necessarily somewhat roundabout, because the chronograph does not tell one the actual velocity of the shot at any given point, but merely records the time occupied by the shot passing from one point to another, and thus indicates the mean velocity throughout that distance. Such are the results included in Mr Griffith's tables, which show first the mean velocity of the shot in 5 yards, then the mean in 10 yards, and so on up to the mean in 60 yards; so that each distance is included in the next longer range, and the actual velocity is not given at any point. Professor Bashforth's work shows, however, that the mean velocity of the projectiles he had under consideration is, for any short range, practically the same as the actual velocity at the middle of that range; and from the actual speed thus ascertained at one point, calculations either backwards or forwards are readily made by means of his tables, so that the velocity at any other point, whether it be the muzzle of the gun or the extremity of the range, may be likewise ascertained. But, true as this rule is in its application to bullets, as I have ascertained from former experience (for I have found no material difference in the estimate whether the calculation was made from 10 yards or 100 yards), yet I quickly discovered that it would not at all hold good if attempted to be applied to loose shot. Thus, on putting it into operation in connection with Mr Griffith's record relative to the charge of 4drs. powder and 1¼oz. No 6, I found that, working from the 30 yards range, the muzzle velocity brought out by the calculation was represented as 1508 feet per second; tried by the 20 yards range, it appeared as 1492 ft.sec.; and so it fell off, step by step, till the 5 yards range gave it no more than 1279 ft.sec. This seemed pretty conclusive evidence that the mass-movement of the shot, in the early portion of the range, so kept up the speed as to entirely vitiate any theoretical calculation based upon the supposition that the pellets were acted on by the atmosphere in like manner as though each were a single projectile travelling as independently as a bullet. Further investigation showed, too, that 30 yards was the culminating point with that 1¼oz. charge, and that from 35 yards on to 60 yards there was a falling off at every step, as the influence of the early mass-movement dwindled more and more away. Somewhat similar results were obtained from the records of 1oz. and 1⅛oz. charges, except that the culminating point came at 20 or 25 yards, and that, with small charges of powder the divergencies were less.

It appeared, therefore, as though the crude notion previously mentioned had some approximation towards the real facts of the case; and, on working out the theoretical velocities of a single pellet of No. 6 shot and of a 12-bore ball of such specific gravity that it would weigh 1¼oz., I p'aced them alongside the velocities derived from Mr Griffith's experiments with the heavy pigeon-shooting charge of 1¼oz. of No. 6, fired with 4drs. of powder. His 5-yards record with this charge shows that the mean velocity of that distance was 1199 feet per second; and such I have taken as the actual velocity at 2½ yards from the muzzle. A calculation upon this basis, applied to a single pellet of No. 6, gives 1279 ft sec. as the velocity at the muzzle; and a similar calculation applied to the 1¼oz. bullet gives a muzzle velocity of 1211 ft.-sec. The actual muzzle velocity of Mr Griffith's 1¼oz. charge is unknown, but probably is a few feet higher than that of the solid bullet. The calculated theoretical velocities, on being placed alongside the velocities derived from Mr Griffith's records, appear as follows; but I have not thought it necessary to show the solid ball velocities beyond the first few ranges.

1¼ Oz. No. 6 Shot and 4 Drs. Powder.

Distances.	Velocities from Experiments. ft.sec.	Calculated Velocities. Solid Ball. ft.sec.	Single Pellet. ft.sec.
At Muzzle	unknown	1211	1279
„ 5 yards	1179	1188	1128
„ 10 „	1140	1166	1012
„ 15 „	1070	1145	922
„ 20 „	986	—	848
„ 25 „	898	—	785
„ 30 „	790	—	730
„ 35 „	668	—	683
„ 40 „	584	—	640

On examining these figures it will be seen that the theoretical loss of speed on the solid ball in the first five yards is only 23 ft.sec., whereas that on the single pellet is 151 ft.sec., and the loss on the actual charge is unknown. In the next range, of a like distance, the loss of speed in the actual charge is 39 ft.sec.; in the solid ball it is 22 ft.sec., and in the single pellet 116 ft.sec.; while in

subsequent ranges the respective losses go on as in the following table:

Range	Loss of Velocity. Actual charge. ft.-sec.	Solid Ball. ft.-sec.	Single Pellet. ft.-sec.
0— 5 yards	unknown	23	151
5—10 ,,	39	22	116
10—15 ,,	70	21	90
15—20 ,,	84	—	74
20—25 ,,	88	—	63
25—30 ,,	108	—	55
30—35 ,,	122	—	47
35—40 ,,	74	—	43

It will be observed that in the theoretical velocities with ball and pellet there is a continued diminution in the loss of speed from step to step; and such is what really occurs with rifle bullets and cannon balls; but with loose shot there appears to be a gradual increase in the proportion of loss up to the point where the charge altogether breaks up, and from that point the loss of speed gradually diminishes. Nevertheless, the actual loss of velocity towards the end of the range seems to be greater than the theoretical reduction on a single pellet moving at similar speed. But we know that, in rowing contests, a boat which receives the "wash" from its rivals is greatly retarded; and it seems very probable that, when the pellets receive the atmospheric "wash" from their numerous companions, they travel less rapidly than when going through "smooth water."

By way of contrast with the results shown by the pigeon shooting charge used in the experiments just alluded to, I next give the figures that apply to the 1oz. charge of No. 6 shot with 3drs. of powder, based on Mr Griffith's mean velocity of 1154 ft.sec. in the 5 yards range:

1 Oz. No. 6 Shot and 3 Drs. Powder.

Distances.	Velocities from Experiments. ft.sec.	Calculated Velocities. Solid Ball. ft.sec.	Single Pellet. ft.sec.
At Muzzle	unknown	1170	1229
,, 5 yards	1129	1141	1068
,, 10 ,,	1076	1114	982
,, 15 ,,	1002	1089	898
,, 20 ,,	906	—	827
,, 25 ,,	789	—	767
,, 30 ,,	712	—	715
,, 35 ,,	678	—	669
,, 40 ,,	636	—	629

Range.	Loss of Velocities. Actual Charge. ft.sec.	Solid Ball. ft.sec.	Single Pellet. ft.sec.
0— 5 yards	unknown	29	141
5—10 ,,	53	27	106
10—15 ,,	74	25	84
15—20 ,,	96	—	71
20—25 ,,	117	—	60
25—30 ,,	77	—	52
30—35 ,,	34	—	46
35—40 ,,	42	—	40

Here, with the smaller charge of shot, a rather larger loss of velocity occurs at the beginning, and the general break up takes place between 20 and 25 yards; yet the remaining velocity at 40 yards stands a good deal higher than that of the larger charge previously given—though whether that is due to there being less "wash" with the smaller number of pellets I am unable to say. Again, in the following table, where the powder-charge is 3drs., as in the last, but the shot increased to 1⅛oz., there is a little less regularity, and, although the pattern would be larger, the velocity at 40 yards falls below the theoretical number, though not to the same extent as with the 1⅛oz. charge. Mr Griffith's mean velocity of this charge in the first 5 yards was 1119 feet per second.

1⅛ Oz. No. 6 Shot and 3 Drs. Powder.

Distances.	Velocities from Experiments. ft.sec.	Calculated Velocities. Solid Ball. ft.sec.	Single Pellet. ft.sec.
At Muzzle	unknown	1130	1190
,, 5 yards	1092	1103	1058
,, 10 ,,	1039	1087	959
,, 15 ,,	991	1067	879
,, 20 ,,	918	—	811
,, 25 ,,	798	—	753
,, 30 ,,	701	—	702
,, 35 ,,	661	—	659
,, 40 ,,	615	—	620

Range.	Loss of Velocities. Actual Charge. ft.sec.	Solid Ball. ft.sec.	Single Pellet. ft.sec.
0— 5 yards	unknown	22	132
5—10 ,,	53	21	99
10—15 ,,	48	20	80
15—20 ,,	73	—	68
20—25 ,,	120	—	58
25—30 ,,	97	—	51
30—35 ,,	40	—	43
35—40 ,,	46	—	39

I have not attempted to go through the results of the three other charges used by Mr Griffith, as, not only would they occupy a good deal more space, but they are less generally used than those I have selected. Neither have I carried those here given beyond the 40 yards range, for the double reason that the farther they go the more irregular they become, and, if carried on to the full extent, they could not be compared with the theoretical results, because Mr Bashforth's tables do not provide for calculations below 500 ft.sec., and some of these go down nearly to 300 ft.sec.

I may add that I estimated the velocities from the experiments by finding the respective times for every five yards from Mr Griffith's mean velocities, and then, after ascertaining the separate velocities for every two ranges, taking the mean as representing the actual velocity required. Thus, from the difference of time in the 15 yards range and the 20 yards range, the velocity at 17½ yards can be found; and from those of 20 and 25 yards, the velocity at 22½ yards can be found in a similar way; and having obtained these two, the velocity at 20 yards may be found as the mean between 17½ and 22½ yards. The process is complicated and troublesome, but it seemed to give the fairest results obtainable; and, although it may not compare for accuracy with the calculations for rifle bullets obtained by much simpler means, I believe it to vary but very little from the true velocities, and to be as close as one can expect to get from such shifting materials as loose pellets. T.

(*Field*, Dec. 25, 1886; Vol. 68, p. 918.)

In the previous article I have attempted to give an idea of the way in which charges of loose shot move through the air for some distance after leaving the muzzle of the gun, and the variations that occur in the deterrent effect of the atmosphere according as circumstances are in operation which promote or prevent a scattering of the pellets. In illustration of the argument I gave some tables of velocities derived from the records of Mr. Griffith's experiments, showing how the falling off in speed occurred with three different charges of No. 6 shot. Since then I have made similar abstracts from such of Mr. Griffith's records as relate to No. 5 shot, and they are here presented in a single table without any of the theoretical accessories which were appended for explanatory purposes in the former article. It will be seen that there are six variations in the charges, and that they are here arranged in the order of the initial velocity, or, rather, of the velocity at the shortest distance from the muzzle at which any estimation can be made. The actual velocities at the muzzle would probably be from 15 to 20 feet higher than those stated at 2½ yards.

VELOCITIES OF No. 5 SHOT (218 PER OZ.) AT DIFFERENT DISTANCES.

Charge.	2½ yds.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.
4drs. and 1¼oz....	1207	1192	1152	1085	1002	920	814	700	655
3½ ,, 1⅛ ,, ...	1182	1168	1105	1022	946	864	797	712	669
3 ,, 1 ,, ...	1160	1136	1080	1005	917	820	743	690	641
3½ ,, 1¼ ,, ...	1130	1113	1065	1010	944	846	758	676	597
3 ,, 1⅛ ,, ...	1127	1095	1045	1003	939	846	738	680	642
2½ ,, 1 ,, ...	996	979	936	852	782	739	721	664	614

In most instances the above figures keep very close to those which relate to No. 6 shot. The initial velocity is a trifle higher with No. 5—a direct effect of the pellets being larger in size, and consequently producing a smaller amount of friction in the barrel. The charge which best suits Mr. Griffith's gun would appear to be 3½drs. and 1⅛oz., as this shows the highest velocity at 40 yards with both sizes of shot; but with two other charges this gun seems to do better with No. 5 than with the smaller-size pellets, as will be seen by reference to the following table, which gives, in similar fashion, the velocities with all the charges of No. 6:

VELOCITIES OF No. 6 SHOT (270 PER OZ.) AT DIFFERENT DISTANCES.

Charge.	2½ yds.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.
4drs. and 1¼oz....	1199	1179	1140	1070	986	898	790	668	584
3½ ,, 1⅛ ,, ...	1175	1155	1095	1003	909	846	777	697	664
3 ,, 1 ,, ...	1154	1129	1076	1002	906	789	712	678	633
3½ ,, 1¼ ,, ...	1121	1100	1065	1003	923	837	728	638	583
3 ,, 1⅛ ,, ...	1119	1092	1039	991	918	798	701	661	615
2½ ,, 1 ,, ...	990	967	919	846	765	710	685	649	609

It may possibly interest the users of guns to see how far velocities derived from chronographic experiments accord with records of the shooting powers of guns at 40 yards, as ascertained by means of the force-gauge. Shortly after that instrument was invented, it was pointed out that it might serve as a means of acquiring a knowledge of the approximate velocity of shot at the time of the pellets coming into contact with the target. The registering scale of the machine is marked in accordance with the distance to which the index-needle has been driven by the impact of given weights (in ounces) falling the distance of 1 foot, and consequently having a velocity equal to 8 feet per second at the moment of impact. This velocity, multiplied by the number of ounces in the falling weight, virtually represents the momentum imparted; and a corresponding amount of momentum would be imparted by the impact of a lesser weight moving with a proportionately higher velocity. The force per pellet, as ascertained from the scale of the force-gauge, is recorded in ounces and fractions of an ounce; and as the weight of a pellet of No. 6 shot is equal to the 270th part of an ounce, it is only necessary to multiply the recorded force per pellet by the number 270, in order to arrive at the average velocity of the pellets that strike the plate of the machine. Thus, if the force per pellet were represented as 2·00, the corresponding velocity would be 540 ft.sec.; if the force were 2·20, the velocity would be 594 f.s., and so on. Necessarily such an estimate could only be taken as an approximate representation of the average speed of the pellets striking the plate. The pellets do not all move with equal velocity, and no single speed can be said to represent the facts exactly, whether the record be made by the chronograph or any other means.

This brief explanation of general principles having been given, I will proceed to lay before the reader some of the many force-gauge records which have been published in the *Field*, and will add the corresponding velocities obtained by the method just described, in order that they may be compared with the chronographic velocities at 40 yards stated in the foregoing tables.

First, as a standard of comparison, it may be as well to take the records from the *Field* Gun Trial of 1879, which was carried out with black powder exclusively; but, to avoid confusion, I will not give any but the 12-bore records. The following figures are the averages of twenty-five shots from each gun; and the numbers between parentheses represent the patterns respectively given.

12-BORES AT THE GUN TRIAL of 1879.	Force.		Velocity.
Highest with 3½drs. and 1⅛oz. (187 pattern)	2·19	=	619
Lowest ,, ,, (175)	2·14	=	577
Highest with 3¼drs. and 1⅛oz. (210)	2·39	=	645
Lowest ,, ,, (180)	2·01	=	543
Only one with 3¼drs. and 1⅛oz. (212)	2·25	=	607
Highest with 3drs. and 1⅛oz. (225)	2·22	=	600
Lowest ,, ,, (223)	2·02	=	545
Only one with 3drs. and 1oz. (183)	2·14	=	577

The above-mentioned guns varied from 6lb. 14oz. to 7lb. 4oz., all using the ordinary paper cases, and some of the heaviest guns had the smallest charges.

Next to these I will give the results of some experiments carried out by Mr. W. P. Jones with black powder (C. & H. No. 4), E.C., and Schultze, as reported in the *Field* of July 29, 1882. The gun was a 12-bore of 6¾lb. weight (chambered for 14 brass "Perfect" cases), the same barrel being used throughout with 1⅛oz. No. 6 shot; and the pattern was remarkably even with the three powders—being, with 3drs., 226 black, 226 E.C., and 227 Schultze; and 227, 225, and 229 with 3¼drs. Six rounds were fired with 3drs. and ten rounds with 3¼drs. of each of the powders,* the respective averages being as follows:

	3 DRAMS. Force.		Velocity.	3¼ DRAMS. Force.		Velocity.
Black powder	2·34	=	632	2·41	=	650
Schultze ,,	2·32	=	627	2·45	=	661
E.C. ,,	2·29	=	618	2·48	=	670

One of the idiosyncracies of guns, to which allusion has recently been made in the *Field*, is here exemplified. With 3drs., black was first, Schultze second, and E.C. third; but with the addition of another quarter of a dram there was a complete *volte face*—the first being last and the last first. With this gun, all the powders scored higher than the best with the corresponding charges at the 1879 trial; but it must not be concluded that was merely the result of using "Perfect" instead of paper cases. In February, 1885, Mr. Jones gave the results of other experiments with two similar 12-bores (14 "Perfect"), somewhat heavier in weight, the gun numbered 12,512 being 6lb. 13oz., and 12,516 weighing 7lb. 4oz. Neither of them came up to that above mentioned as regards force; but the results are curious, as showing how differently the guns behaved with equal charges of the same powders, and how the force varied in the first gun when the patterns were practically equal. The charge was 3drs. and 1⅛oz. No. 6.

	Force.		Velocity.
Gun No. 12,516, with C. & H. No. 4 (209 pattern)	2·22	=	600
,, ,, Schultze powder (207)	1·97	=	532
Gun No. 12,512, with C. & H. No. 4 (202)	2·02	=	545
,, ,, ,, No. 6 (235)	2·25	=	607
,, ,, Schultze powder (237)	2·25	=	607

In the one gun, No. 4 black powder gave much more velocity than Schultze; in the other No. 4 was as far behind, but No. 6 and Schultze were on even terms. In a gun with paper cases (No. 11,071), Schultze powder gave the very same results as just stated, viz., 237 pattern and 607 velocity; while No. 6 black was rather lower.

In another gun with paper cases (No. 11,192, 7lb. 2oz.), Mr. Jones tried the new brown powders in comparison with C. & H. No. 4. The charge was 3½drs., but the velocity was not so great as with 3drs. in some of the other guns, as will be seen by the following records, taken from the *Field* of April 3, 1886:

	Force.		Velocity.
C. & H. No. 4 black (206 pattern)	2·14	=	577
,, medium brown (236)	2·15	=	580
,, coarse brown (231)	1·94	=	524

Records of trials with No. 5 shot are not nearly so numerous as with No. 6; nevertheless a few facts may be found. In Mr. Griffith's experiments of 1879 he tried various charges of No. 5 as well as other sizes, and these I propose to quote. At the time of the 1879 Gun Trial, the Editor tried a 12-bore of 7¼lb. with No. 5 as well as No. 6, the powder used being C. & H. No. 6. The results were as follows:

	Force.		Velocity.
3 drs. and 1⅛oz. No. 6 (197 pattern)	2·34	=	632
,, ,, ,, No. 5 (155)	2·69	=	590

This gun did better with No. 6 shot than with No. 5. The force of the larger pellets was, of course, greater, there being only 219 pellets to the ounce, instead of 270; but when the force per pellet is multiplied by 219, it shows the velocity to be less than that of No. 6.

The gun used in Mr. Griffith's experiments of 1879, quoted below, not being full choke, gave smaller patterns and less force than most of the guns above mentioned; but by stating the results with No. 6 as well as No. 5 a comparison may be made. Several different charges were used, both of C. & H. No. 4 and Schultze, but I give only those in which the charges of powder and shot were the same as

* When charges of the nitro-compounds are stated in drams, the equivalent of that weight of black powder is, of course, meant; *i.e.*, at the rate of 42 grains of the nitro-compound for 3 drams of black.

stated in the foregoing tables of velocities—in which, however, a full choke was used.

No. 5 Shot	Black Powder. Force.	Velocity.	Schultze Powder. Force.	Velocity.
3¼drs. and 1⅛oz.	2·74	600	2·47	542
,, ,, 1⅛ ,,	2·16	473	2·37	520
3drs. ,, 1⅛ ,,	2·41	528	2·63	580
,, ,, 1 ,,	2·38	522	2·25	492
2¾drs. ,, 1 ,,	2·17	475	2·33	510
No. 6 Shot.				
3¼drs. and 1⅛oz.	1·72	465	1·77	478
,, ,, 1⅛ ,,	1·85	500	1·94	523
3drs. ,, 1⅛ ,,	1·84	498	1·93	520
,, ,, 1 ,,	1·88	508	1·87	505
2¾drs. ,, 1 ,,	1·57	423	1·73	468

It is curious to remark, especially with the No. 5 shot, how one powder did better with one charge, and worse with another; also that both did better with 3drs. and 1⅛oz. than with 3¼drs. The extra half dram, in this gun, evidently expended its energy in scattering the pellets, and thus reducing their speed, as the pattern of No. 5 with 3drs. was 148 black and 147 Schultze, but with 3¼drs. the pattern fell to 125 and 126; and this falling off of more than 20 pellets in the pattern was accompanied by a reduction of 50 to 60 feet per second in the velocity, notwithstanding that the larger charge of powder must have given greater speed at the muzzle.

Many equally curious results are shown in the records of other experiments, where wads have been altered, different cartridge cases used, and so on, as the effects are not the same on the different powders; but it would take too much space to treat of these matters in the present article, and I will merely add here that many owners of guns would, I think, have a far better idea of the killing power of their guns if they were informed of the striking velocity at 40 yards as well as the force per pellet. The meaning of 2·22 oz. force does not present itself so clearly to the imagination as 600 feet per second; and those gunmakers who have the force-gauge, with its attendant printed tables, may readily convert the force records into velocity, by a reversal of the process whereby they turn the record on the gauge into force per pellet. T.

EFFECTS OF WADS ON VELOCITIES OF SHOT.

(*Field*, Jan. 8, 1887; Vol. 69, p. 40.)

Besides the variations of velocity arising from causes alluded to in my previous article (*Field*, Dec. 25, 1886), such as an alteration of charge or change of gun, considerable differences are produced when gun and charge are the same, and all conditions are exactly alike, except as regards the wads that are used. A very good illustration of the effect produced in this way was published by Mr. Leeson in the *Field* of May 2, 1885, where he gave particulars of a series of experiments with 42grs. E.C. powder and 1⅛ oz. No. 6 shot, in a 12-bore gun, with Eley's cartridges, the same mode of loading being adopted throughout, except that the wad used between the powder and the greased felt was changed after every five shots. The respective averages at 40 yards were as follows:

	Force.	Velocity.
With 11¾ *Field* wad, ¼in. thick (231 pattern)	2·45	661
,, best white cloth wad (224)	2·35	634
,, thick card ,, (188)	2·27	613
,, thin card ,, (184)	2·26	610
,, thin grease-proof ,, (184)	2·19	591

The great loss of velocity which accompanied a scattering of the pellets will be obvious on comparing the respective patterns with the corresponding velocities. But these, it must be remembered, are only averages after all; and, when one examines, shot after shot, the details given by Mr. Leeson, the great differences of regularity or irregularity in shooting of the respective batches of cartridges make it clear that there must also be a wide difference in the probability of killing game with some of them as compared with others. Thus, with the tight 11¾ wad, the average of 231 in pattern, on the 30in. target, was made up of numbers from 229 to 232—a variation of only three pellets; with the white cloth wad, the pattern varied from 201 to 245; with the thick card the variation was from 123 to 242, and with the thin card from 100 to 243; but the thin grease-proof wad gave the widest divergency, the smallest pattern being 84 and the largest 250. It is remarkable that a gun which shot so regularly as to show a difference of only three pellets on the target in five successive shots, should, by merely changing the wad over the powder, increase the dispersion to such an extent that two-thirds of the charge should fail to strike the target; while those pellets which did hit the plate showed a falling off of 70 feet per second in their velocity.

In the experiments just mentioned, the powder used was E.C., and the wads changed were those in immediate contact with the powder. It appears, however, that this is not the only wad which affects the regularity of shooting; nor must the differences produced be declared to apply solely to nitro-compounds, for with so old and steady-going an explosive as No. 6 black there are some variations on record that are worth quoting. In the *Field* of May 1, 1880, are particulars of an experiment carried out by Mr. W. P. Jones, in which the charge used was 3drs. of C. & H. No. 6 powder and 1⅛oz. No. 6 shot—the *Field* mode of loading, including the thin card wad *over the shot*, being adopted in one batch of cartridges, but in the other batch a cloth wad ⅛in. thick was substituted for the thin card. The effect produced by the change is shown in the following averages:

	Force.	Velocity.
With thin card over the shot (213 pattern)	2·02	545
,, ⅛in. cloth wad ,, (165)	1·93	520

This change of the final wad caused such a dispersion of the shot that 48 pellets less struck the target on the average, and the successive cartridges were more irregular. With the thin card over the shot the pattern varied from 206 to 230—a difference of 24; with the thick cloth wad the pattern varied from 125 to 194—a difference of 69; and the scattering of the pellets was accompanied, as usual, by a loss of speed.

Another of Mr. Jones's experiments is interesting as showing how evenness in shooting goes hand in hand with regularity in the wads and loading. In the *Field* of April 10, 1886, are given the particulars of this experiment, carried out with a 6½lb. 12-bore gun, 28in. long, loaded with 42grs. of E.C. and 1⅛oz. No. 6 shot, in Bailey's gas-tight cases. The cartridges were loaded alike throughout, with 11¾ *Field* wads next the powder; but in one batch of ten cartridges the 11¾ wads, were taken indiscriminately, whereas, for the second batch, Mr. Jones selected the 11¾ wads, so as to ensure their all being of one uniform thickness, and he then rammed the charge to exactly the same extent each time by means of his gauged rammer. The difference of result produced by this extra care in loading is shown by the following averages:

	Force.	Velocity.
With wads taken indiscriminately	2·06	555
,, selected wads	2·26	610

In the average pattern the difference was small—there being 234 with the former and 239 with the latter; but in regularity with the successive shots there was a considerable difference, as will be seen by the annexed comparative table:

	Unselected Wads. Pattern.	Force.	Velocity.	Selected Wads. Pattern.	Force.	Velocity.
Average of ten shots	234	2·06	555	239	2·26	610
Highest	274	2·24	602	250	2·45	662
Lowest	183	1·82	490	220	2·18	592
Difference	91	·42	112	30	·27	70

One of the most noteworthy series of experiments of this kind was carried out a few months ago by Mr G. Thorpe Bartram, who gave the detailed results in the *Fields* of June 26 and July 3, 1886. Here the new issues of E.C. and Schultze powders were tried under exactly the same conditions, in a fully-choked 12-bore, weighing 7lb. 2oz., with 30in. barrels made of Whitworth steel. Mr Bartram's general remarks on the points of difference between the two powders are well worth reading; and what he says of each with respect to wads is quite confirmatory of what is stated above in reference to the experiments previously carried out by Mr Leeson and Mr Jones. Relative to the mode of loading, Mr Bartram remarks: "There is this important particular to be noted, that in each instance I found the penetration decrease when the *Field* wad was omitted, and also that a thin card wadding over the shot produced the best figure of merit." This was in his letter about Schultze powder, but in the following week he said the same in substance with respect to E.C., and in rather more forcible terms. But the special point to which I wish now to draw attention is the difference of effect produced upon the two powders by merely changing the cartridge cases—every other condition remaining the same.

Four kinds of cartridge cases were used by Mr Bartram with the one powder, and three with the other (I do not see any reason stated for this, and merely mention the fact to explain the blank below).

Ten shots were fired of each batch, the averages being as follows with the respective powders, and the numbers between parentheses applying to the patterns:

	E.C. Powder. Force.	Velocity.	Schultze. Force	Velocity.
Eley's cases (E.C. 232, S. 238)	2·03	= 548	2·34	= 632
Joyce's ,, (E.C. 246, S. 225)	2·17	= 586	2·37	= 640
Kynoch's ,, (E.C. 234, S. 226)	2·56	= 690	2·30	= 620
Bailey's ,, (E.C. 229)	2·31	= 623	—	—

As will here be seen, the pattern did not vary greatly, and the numbers were high in all cases, the gun evidently shooting very closely; but a considerable difference was exhibited in the force of the two powders when the cases were changed. Whichever case was adopted, the change was but small with Schultze, the force varying only from 2·30 to 2·37, equivalent to velocities of 620 and 640 feet per second; whereas the variation with E.C., consequent on the change of cases, was very remarkable, ranging from 2·03 to 2·56 in force, or 548 to 690 feet in velocity. It would appear from this that E.C. is much more sensitive to changes in strength of caps and difference of flash-holes than the other nitro-compound; and as the new Kynoch case has a stronger cap and larger space for the flash to pass into the powder than the other cases here used, the great increase of propulsive force is doubtless thus accounted for. Of course such additional force would not be obtained without some increased strain upon the barrel; but that is outside the scope of the present article, and information on this point will be found by referring to Mr. Bartram's letters.

That E.C. powder, with Kynoch's new "perfectly gas tight" cases, must have imparted to the shot in Mr. Bartram's gun a higher initial velocity than was given by the other cartridges, seems very evident when the details are examined. There was not any such dispersion of pellets as would suffice to account for the falling off of force with the Eley cases. The average patterns with the two kinds of cartridges differed only by two pellets, and in regularity of shooting with successive rounds Eley's stood the first of the whole lot, the deviations from the respective averages being—Eley 11, and Kynoch 17, with Bailey and Joyce intermediate; nevertheless, on ten rounds from each being fired, the force exhibited by Kynoch exceeded, in nine shots out of ten, the highest round in the Eley series. And, strange to say, the extra propulsive force appears, in this instance, to have had the effect of concentrating the charge somewhat in the centre; for, although there were only two pellets difference between Eley and Kynoch on the 30in. target, there was a difference of thirteen on the 10in. plate—the averages being, Eley 59, Kynoch 72. From this one would naturally expect a higher striking force in the latter, even if the initial velocity were exactly the same, as the more concentrated the pellets, the less is the loss of velocity during their passage through the air. But the concentration will not explain everything in this instance, for in four rounds out of ten the pellets on the gauge were exactly equal in number, yet the force with Kynoch was always higher, as will be seen from the following figures:

	Kynoch's Cases. Force.	Velocity.	Eley's Cases. Force.	Velocity.
55 pellets on 10in. plate	2·13	= 575	1·89	= 510
59 ,, ,,	2·29	= 618	1·95	= 528
61 ,, ,,	2·52	= 680	2·15	= 580
63 ,, ,,	2·38	= 642	2·26	= 610

It is curious, too, that the same cartridge cases which tended to produce concentration with the E.C. powder, tended to dispersion with Schultze, when used in the same gun. In average pattern Schultze was only eight pellets less than E.C. on the 30in. target, but it had twenty pellets less on the central 10in. plate; and successive rounds were much more irregular with the Kynoch than with the Eley case—the divergence from the average with the former being about double as much as with the latter. Consequently, on the whole, the average force, when Schultze was used, was lowest with the Kynoch cartridges, although in those rounds where the pellets on the gauge were equal, or nearly so, the force recorded was highest with Kynoch; and thus it may be inferred that, with Schultze powder likewise, a higher initial velocity was imparted by the extra strength of the Kynoch cap, but that it here caused a dispersion of the pellets, and so eventually led to a reduction of their speed.

There is but one other matter that I propose to touch upon as regards the influence of the mode of loading on the velocity of the shot, and that is with reference to the amount of pressure on the powder. For the last seven or eight years it has been known that, if Schultze powder be heavily pressed, it does not shoot so well as when the pressure is light; and consequently, excep by persons who are very careless, or utterly ignore the instructions upon the canisters, a heavy pressure with this powder is generally avoided. Many people, however, who acknowledge this principle with respect to Schultze, hold that it is necessary to use a heavy pressure when loading E.C.; and it may therefore be desirable to show what has been the result when the different modes of practice have been tested systematically. Mr. Bartram, in his letter of July 3 last says, with respect to E.C. powder: "I may add that very tightly rammed cartridges do not do so well at the target as those of which the powder wads are only pressed home firmly." And this, although it does not go into details, is quite confirmatory of what had been shown by Mr. Jones in the *Field* of March 13 and 27, 1886, where full particulars are given. The gun he used was the 28in. 12-bore previously mentioned, with paper cases (maker not stated), and four different samples of E.C. powder, the cartridges being loaded exactly alike, except that in one half of them the powder was only moderately pressed (*i.e.*, to the extent of $\frac{1}{16}$ of an inch on Jones's gauged rammer), whereas in the other half the pressure was very heavy (*i.e.*, $\frac{3}{16}$ of an inch on the gauged rammer). The charge was 42grs. E.C. with 1⅛oz. No. 6 shot, and the averages were as follows:

	Moderate Pressure. Pattern	Force.	Velocity.	Very Heavy Pressure. Pattern.	Force.	Velocity.
No. 1 sample	228	2·18	= 589	185	1·84	= 492
,, 2 ,,	225	2·06	= 556	206	1·94	= 523
,, 3 ,,	236	2·31	= 623	174	1·87	= 505
,, 4 ,,	230	2·07	= 558	174	1·72	= 465
Mean of four samples	230	2·16	= 582	185	1·84	= 497

Here it will be seen that, on the average of the four samples, the result of heavily ramming the powder was to reduce the pattern by 45 pellets, and to cause a falling off in the velocity of 85 feet per second; and an examination of the details shows that the patterns were regular with the moderate pressure and irregular with the heavy pressure. The evidence, however, does not rest on a single experiment, as Mr Jones carried out a similar trial a fortnight afterwards with one sample of E.C., in Kynoch's cartridges, loaded with three different pressures, viz., moderate ($\frac{1}{16}$in.), heavier ($\frac{2}{16}$in.), and very heavy ($\frac{3}{16}$in.), the averages being as follows:

	Force.	Velocity
Moderate pressure (229 pattern)	2·15	= 580
Heavier ,, (203)	1·94	= 523
Very heavy ,, (145)	1·89	= 510

Besides the falling off in the number and velocity of the pellets, the patterns became more irregular as the pressure increased; and Mr. Jones said that, "With the three-sixteenths pressure the shooting was very wild indeed." How wild it was will be seen from the fact that four successive shots gave such patterns as 217, 97, 96, and 190 on the 30in. target, while the numbers on the central 10in. plate varied from 15 to 55. If, after this, anybody prefers to have his E.C. powder heavily rammed, one must either suppose that his gun behaves very differently from Mr. Jones's, or else admit that "There's no accounting for tastes."

Before closing, I will present tables of velocities of No. 7 and No. 8 shot, derived from the mean velocities of Mr Griffith's chronographic records, in like manner as those of No. 5 and No. 6 shot given in my previous article:

Velocities of No. 7 Shot (340 per oz.) at Different Distances.

Charges.	2½ yds.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.
4drs. and 1¼oz.	1186	1166	1120	1042	938	842	750	673	587
3½ ,, 1⅛ ,,	1163	1141	1088	990	892	819	757	691	615
3 ,, 1 ,,	1147	1125	1080	997	881	811	713	638	566
3½ ,, 1¼ ,,	1110	1083	1049	997	909	802	691	620	559
3 ,, 1⅛ ,,	1091	1070	1023	957	859	781	688	617	576
2½ ,, 1 ,,	976	959	919	837	761	710	664	624	551

Velocities of No. 8 Shot (448 per oz.) at Different Distances.

Charges.	2½ yds.	5 yds.	10 yds.	15 yds.	20 yds.	25 yds.	30 yds.	35 yds.	40 yds.
4drs. and 1¼oz.	1162	1149	1111	1036	919	806	717	627	551
3½ ,, 1⅛ ,,	1149	1130	1080	997	898	815	735	644	576
3 ,, 1 ,,	1136	1116	1072	971	842	765	673	604	568
3½ ,, 1¼ ,,	1097	1077	1036	971	881	802	691	585	539
3 ,, 1⅛ ,,	1083	1060	1003	914	824	742	659	585	526
2½ ,, 1 ,,	964	942	898	828	744	676	662	633	536

On comparing these with the two tables in the *Field* of Dec. 25, it will be found that, with each decrease in the size of the shot there is a diminution of about a dozen feet in the initial velocity, owing to

the larger number of pellets causing an increase of friction in the barrel. At the end of 40 yards, however, the falling off in speed is scarcely so great as might be anticipated from the difference in the weight of the pellets; but this is accounted for by the charge travelling in a ball-like mass for some 20 yards or so (the distance varying with the quantity of powder and shot used), and it is not till after the general break up of the charge that the pellets lose speed in proportion to the reduction in their size and weight.

In conclusion I may say that the more I examine into experimental records—whether they relate to gun against gun, increase or decrease of powder and shot, difference of wads, or change of cartridge cases—the more am I convinced that it is unwise in those who wish to make the best use of their weapons, to spend a large sum of money in buying a gun and then trust to chance as to the manner of loading it. Guns have their peculiarities as well as their owners; and the former will no more shoot well with all sorts of cartridges than the latter will shoot well with all sorts of guns. Unless the owner of a gun is convinced that it is already doing its best—and where he has not the opportunity or inclination to personally carry out experiments for the purpose of determining its capabilities—he would do well to put it into the hands of a thoroughly practical gunmaker, who is accustomed to such experiments, and not too high-minded to pass his own work under review, or to see what can be done with the work of another maker. It is worth a little outlay to ascertain whether one powder suits your gun better than another, and what charge it does best with—what cases and wads produce the pattern that best meets your requirements, with the greatest force obtainable, and a certainty of not going from one extreme to another in successive shots. And, having got the required information, get your cartridges loaded by someone whom you can rely upon to work to order, and do not risk spoiling your bag in the attempt to save a shilling or two in a hundred cartridges, when the extra cost is called for by the wads being of a special nature or the mode of loading necessitating additional care and attention. T.

EXPERIMENTS TO ASCERTAIN THE VELOCITY OF FLIGHT OF BIRDS.

(*Field*, Feb. 19, 1887; Vol. 69, p. 242.)

THE rate of speed attained by birds that are commonly shot at by sportsmen has been the subject of a good deal of discussion in the *Field*, and very conflicting opinions have been expressed with respect to their powers of flight. In order, if possible, to obtain data of a more reliable character than many vague surmises which have been indulged in, we requested the assistance of Mr. Griffith, who has from time to time furnished our readers with so much valuable information relative to the velocities of shot and the explosive force of gunpowders; and he not only very kindly complied with our request, but has improved upon the method we suggested for carrying out the experiments.

The series of trials was commenced with pigeons, which it was thought might probably be more amenable than wild game to the conditions connected with their flight, and so, in the event of there being any hitch in the arrangements, there would be a better chance for the apparatus to be got into thorough working order before attempting experiments with partridges or pheasants. In order to secure a good standard of comparison, Mr. Hammond, the well-known purveyor of pigeons for the Hurlingham Club, was asked to select some of his very best "blue rocks" to pass through the ordeal. The experiments with these birds were carried out about two months ago, on a fine clear day in the middle of December, when there was no wind whatever to enhance or diminish the natural speed of the birds.

The pigeons commenced their flight at one end of the covered range, or experimental shooting gallery, of the Schultze Gunpowder Company, in the New Forest, and the birds thus had the opportunity of getting well on the wing before they reached the other extremity, where was placed the apparatus employed to record their rate of speed after they had flown 40 yards. Two "screens," or arrangements of fine threads, were here put into connection with the electric apparatus, and through these threads the birds must necessarily dash in their flight, in order to make their exit from the range. The so-called "screens" were composed of the finest invisible-grey cotton, so easily broken as not to check the flight of the birds in the slightest degree, and the successive breakages were instantaneously recorded by the electrical apparatus. Between the two screens there was an intervening space of 6ft. 9in. (a distance which was adopted from its being convenient for regulating the chronograph), and, the apparatus having recorded the time taken by the bird in traversing this 2¼ yards interval, the velocity was then readily convertible into yards per second or miles per hour.

In order that the birds might fly directly towards these screens, all apertures in the building were darkened except the open end of the range; and, as the birds, on being liberated, would naturally fly towards the broad daylight, and be likely to gain full confidence as they approached the place of exit, it was hoped that each of them might be led to do its best by the time it reached the point where the record of speed was to be made. The results, on the whole, were very satisfactory. Now and then a bird would not fly straight, or would check its flight before dashing through the screens; but, whenever such was the case, the record was rejected as defective, and accordingly does not figure in the list which is given below. The number of good flights, however, was sufficient to enable Mr. Griffith to make twelve fair records of speed, the particulars of which are as follows:

Pigeons in the 40 Yards Range.	Time.	Rate of Speed.	
	Seconds.	Yards per Second.	Miles per Hour.
1st	·157	14·3	29·3
2nd	·156	14·4	29·5
3rd	·168	13·4	27·4
4th	·150	15·0	30·7
5th	·163	13·8	28·2
6th	·139	16·2	33·1
7th	·169	13·3	27·2
8th	·153	14·7	30·1
9th	·168	13·4	27·4
10th	·176	12·8	26·1
11th	·157	14·3	29·3
12th	·136	16·5	33·8

Having obtained the above chronographic results in the covered range, Mr. Griffith was not content to let matters end there, and he therefore determined to place these velocities in comparison with records of flight in the open. For this purpose he adopted a method very similar to that which has since been suggested by "Vivarii Custos" (*Field*, Jan. 15) as a means of ascertaining the flight of driven partridges. Mr. Griffith placed men in ambush at various measured distances, with instructions to signal as soon as a bird arrived opposite either of the stations. When the bird had flown twenty-five yards from the starting point in the open, the time was taken by means of a stop watch, and the record was completed as soon as the signal was given of the bird having accomplished either of the measured distances. In four instances the birds went straight away, and the records were as under:

Flight of Pigeons in the Open.	Time.	Rate of Speed.	
	Seconds.	Yards per Second.	Miles per Hour.
240 yards	19	12·6	25·8
265 ,,	20	13·2	27·0
300 ,,	22	13·6	27·9
132 ,,	10	13·2	27·0

With reference to these results Mr. Griffith says: "I expected the free long flight would beat the chronograph velocities at 40 yards, but the reverse is the case. I imagine the reason is, that when started from a trap or basket, as these were, the birds fly in alarm at first, but when away in the open they do not keep up their full pace." In neither case, however, did these "blue rocks" come up to the average speed of the trained "homing birds" of which Mr. Tegetmeier gave particulars in the *Field* of Jan. 22, 1887. There the average speed of the winning birds in eighteen pigeon races amounted to 36 miles an hour—the highest velocity, with a favourable wind, being at the rate of 55 miles an hour. In Mr. Griffith's experiments the highest velocity was nearly 34 miles an hour, without any wind whatever.

Mr. Griffith's next task was to try similar experiments with partridges and pheasants, and for that purpose it was desirable to obtain a supply of good wild birds, as those kept in confinement could not be taken as fair representatives of the power of flight of birds which had always been at liberty. The difficulty, however, for many weeks, was to get such specimens as were wanted, the snow upon the ground and other circumstances being unfavourable to their capture. At length, however, some birds were obtained, all very wild and active, and then Mr. Griffith proceeded with his experiments.

The conditions as to screens, &c., were as previously stated. Some of the pheasants were inveterate runners and would not rise to the screens at all; others rose fairly, but they did not all of them exhibit an equal degree of earnestness, and the best six records obtained were as follows, the first being that of a splendid bird, who went

through the screens in fine style. The respective times and velocities were as follows:

Pheasants in the 40 Yards Range.	Time. Seconds.	Rate of Speed. Yards per Second.	Miles per Hour.
1st	·136	16·5	33·8
2nd	·156	14·4	29·5
3rd	·186	12·1	24·7
4th	·189	11·9	24·4
5th	·225	10·0	20·5
6th	·139	16·2	33·1

Some of the birds were also timed in the open, and, as on the day of the previous experiments, there was no wind whatever. Two of the pheasants went away straight at fine speed; a third doubled back, and is therefore omitted from the record; and the fourth went straight away, but with much less velocity than the first two. From the following records it will be seen that, contrary to the experience with the blue rocks, the pheasants attained their highest speed in the open:

Flight of Pheasants in the Open.	Time. Seconds.	Rate of Speed. Yards per Second.	Miles per Hour.
265 yards	15·0	17·7	36·1
220 ,,	11·8	18·6	38·1
140 ,,	10·6	13·2	27·0

The concluding experiment was with the partridges, which went fairly well at the screens, though they did not seem to exert themselves very much; and the following were the records obtained:

Partridges in the 40 Yards Range.	Time. Seconds.	Rate of Speed. Yards per Second.	Miles per Hour.
1st	·172	13·1	26·8
2nd	·188	12·0	34·5
3rd	·194	11·6	23·7
4th	·162	13·9	28·4

Here, in the range, the partridges did not fly so fast as the blue rocks; but they did better in the open, so far as the records go. Only two of them, however, flew far enough to have their time recorded. The rest dropped to the ground before they got to the men who were stationed to signal their arrival. The speed of these two were as follows:

Flight of Partridges in the Open.	Time. Seconds.	Rate of Speed Yards per Second.	Miles per Hour.
170 yards	12·6	13·5	27·6
220 ,,	14·0	15·7	32·1

Mr Griffith says, in conclusion: "I think the velocities may be fairly taken as the speed of birds rising to the gun, and also of driven game when not aided by any wind." Of course, when driven birds are going down wind with all the advantage of a strong breeze, the velocity of the wind has to be added to the natural speed of the bird; and the difference will be seen to be no trifle when it is remembered, as meteorologists tell us, that the velocity of the air in "a light breeze" amounts to 14 miles an hour; in "a good steady breeze" it is 21 miles an hour; and 40 miles an hour in "a gale"—which some sportsmen aver that they have shot driven birds in, though the statement may perhaps require to be taken *cum grano*. However, be this as it may, we think that sportsmen in general will join with us in thanking Mr Griffith for the great pains he has taken to throw light upon a subject which has been a source of so much doubt and difference of opinion. T.

THE TIME OF IGNITION OF GUNPOWDERS.

(*Field*, Feb. 11, 1888; Vol. 71, p. 176.)

A FEW remarks which we recently made, relative to the rate of ignition of gunpowders, have given rise to more correspondence than we anticipated; and the following letter, which we have received from an old correspondent, who has from time to time sent us many interesting communications on shooting questions, induces us to go more fully into the subject than we originally intended. Another correspondent, who adopts the pseudonym of "Square-headed Nails," remarked, a fortnight ago, that "It seems a curious thing that Schultze and E.C., being quick-burning powders, should kick less than coarse black, whilst the fine black burns faster and kicks more than the coarse black." What was said by "Square-headed Nails," with respect to coarse and fine black powders, is quite true; but we pointed out that he was under a misapprehension with respect to the above-mentioned nitro-compounds, as they ignite more slowly than the black powders. Last week "A Constant Reader" wrote, taking exception to our remarks, and expressing his opinion that these nitro-compounds ignite more quickly than black powders; and now J. T. B. writes as follows:

SIR,—"Square-headed Nails" is quite correct in considering that quick powders cause less recoil than slow powders, and the fact recorded by him that No. 2 black kicks more than coarse black of itself proves that the combustion of the former is slower than that of the latter when exploded in the bore of a gun. This argument could not be followed to its extreme application—viz., mealed powder—for the ignition is then so much retarded by the absence of air interstices as to bring down the muzzle velocity of the shot nearly 60 per cent. But, comparing powders that give fairly average muzzle velocities to the shot, it is capable of proof that the nitro-compounds kick less than black because they possess a quicker ignition. The manufacture of Schultze has been modified, so that it now kicks more than it used to do, simply because its combustion is more under control, less instantaneous, less violent. The muzzle velocity of the charge has not suffered at all by this change for the better. I say the better because the mechanism of the gun is less strained, and the increased recoil is not worth thinking about. It is a well-known fact that the introduction of slow-burning powders for ordnance has given considerable trouble, owing to the increased recoil and the strains thereby thrown upon the carriages. The dynamics of a shot gun rest upon the same principle as those of a 100-ton gun.

The "violent kicks, damaged actions, and burst barrels that occupied so much of your space four or five years since" were frequently due to unduly large charges being placed in guns of light construction, and possessing powder chambers too long for their diameter, thus producing abnormal strains from wave action—a theory I then propounded, and which you proved by experiment to be correct. If a gun kick violently, that fact of itself should prove either that the shot charge is too heavy or the powder charge too heavy for the gun; and if it should occur with a nitro-compound it also proves that the ignition is not so quick as usual, but that time has been afforded to overcome the *vis inertiæ* of the gun, and project it against the shoulder of the shooter. J. T. B.

With every respect for our correspondent, we must beg to differ from his conclusions. It is undesirable, however, to complicate matters by dwelling on the effect of wave-action in long chambers, and some other points touched on in his letter, so we will merely say that our previous remarks were intended to relate to ordinary 12-bore charges in 12-bore barrels, and the effect produced therein by quickening the combustion of the nitro-compounds. Our investigation of the pressures in small-bores was subsequent to our experiments with 12-bores, and independent of quickened combustion. We had been convinced, by the results of our 12-bore experiments, that Schultze powder, when used in the ordinary way, as issued from the manufactory, was slower in ignition than the black powders; but since then further evidence has been obtained, which places the facts in a still clearer light. We published, more than twelve months ago, a few particulars with respect to the amount of time that elapsed between the pulling of the trigger and the passage of the shot from the muzzle of the gun. These were the results of chronographic experiments carried out by Mr. R. W. S. Griffith, the manager of the Schultze Gunpowder Company's works. Since then the same gentleman has carried out further experiments which demonstrate much more distinctly the rate of combustion with the different powders. They undoubtedly must have caused him a great deal of trouble, owing to the necessity of altering his electrical apparatus in order to make it sensitive enough to record such very minute intervals of time; but the results, now that they have been obtained, are certainly most interesting.

With reference to the mode of obtaining the records, we may say that in the *Field* of Nov. 20, 1886, we published particulars of experiments carried out with Mr. Griffith's crusher-gauge [here reprinted at pp. 29-32], and gave illustrations of the implement. It will be remembered as a thick steel barrel, 30in. long, bored exactly like an ordinary 12-bore, but with the wall of the barrel tapped, so as to admit movable plugs, by means of which pressures are taken on thick leaden discs. In the chronograph experiments now about to be described electrical apparatus was connected with these plugs, instead of inserting lead discs, and times were thus taken instead of pressures. The first plug is situate one inch from the breech, and consequently just at the end of the powder charge, and partly over the powder wads. The second plug is 2¾in. from the breech, and accordingly just clear of the end of the paper case. The third plug is 6in. from the breech, and therefore 2ft. from the muzzle. The charges used were 84grs. of black powder or 42grs. of Schultze, with 1⅛oz. No. 6 chilled shot (270 to oz.), in Eley's ordinary cases, except when the Schultze powder was used in cases made for large caps.

The time from the pressing of the trigger to the blow on the cap may be taken as a constant quantity with the same person, though it may vary with different individuals, and so introduce the "personal equation" alluded to by Dr. Fleming in his article in the *Field* of Feb. 19, 1888. With Mr. Griffith, the releasing of the hammer and its fall occupied ·0022sec.; but it is needless to include this "constant" in the following table, and we therefore commence with the time that elapsed from the striking of the cap until sufficient pressure had been put upon the first plug to start the record; and here the different rates of ignition with the respective powders are most markedly shown.

Schultze is found to be even slower in action than No. 6 black, except when the former is quickened by a large cap, and then the time of getting up to record-pressure is nearly on an equality with No. 4. This first record is, in all probability, made before the resistance of the "turn-over" has been overcome, and consequently before the shot is actually set in motion; and therefore the interval between the records of plugs 1 and 2 may be assumed to represent the first movement of the shot, which with Schultze is in both cases slower than black. Between plugs 2 and 3 the difference between Schultze and the black powders is lessened. After the 6in. plug is passed, Schultze proceeds to make up its lost ground, and surpasses in speed every variety of black powder except No. 2.

Here are the times for comparison; but we have in this table stated the distance from third plug to muzzle as 22in. instead of the full 2ft., because the wire at the muzzle is broken by the wad in *advance* of the shot, whereas the plug records are made by the action of the gas *behind* the shot, and this difference practically lessens the distance traversed by nearly two inches.

Kind of Powder.	Cap to First Plug. (1in.)	First to Second Plug. (1¾in.)	Second to Third Plug. (3¼in.)	Third Plug to Muzzle. (22in.)
BLACK:	Sec.	Sec.	Sec.	Sec.
No. 2	·00158	·00063	·00043	·00126
No. 3	·00182	·00095	·00051	·00132
No. 4	·00209	·00137	·00062	·00142
No. 6	·00255	·00160	·00070	·00145
SCHULTZE:				
Ordinary cap	·00366	·00192	·00072	·00130
Large cap	·00214	·00175	·00072	·00129

Possibly it may strike some of our readers as very extraordinary that, when one powder took double the time of another to effect the first movement, the speed at the other end of the barrel was very nearly equal. But that is not at all unprecedented; and the following brief particulars, extracted from a War Office report of artillery experiments with black powder of four different kinds of grain, tried in a gun of 8in. bore, with shot weighing 180lb. each, show results that are even more remarkable. It will be seen that the slowest-burning powder took eleven times as long as the quickest in moving the shot the first two inches, and yet they were practically alike about 7ft. further on.

Kind of Powder.	First 2 inches.	Second 2 inches.	Next 8 inches.	Last 6ft. 4in.
	Sec.	Sec.	Sec.	Sec.
Rifle Large Grain	·0005	·0003	·0010	·0055
Pellet Powder	·0011	·0005	·0011	·0056
Pebble Powder	·0026	·0007	·0012	·0056
Russian Prismatic	·0055	·0016	·0015	·0056

But, to return to the 12-bore and its charges, it may be of interest to bring together some particulars showing the effect of these differences of combustion on the full amount of time taken between the sportsman pulling the trigger and the shot hitting the bird. We therefore add another table, giving the total time from the fall of the hammer to the shot reaching a target 35 yards from the muzzle of the gun. The respective times from pressing the trigger to the blow of the hammer, from detonation of the cap to shot leaving the muzzle, and from quitting the gun to striking the target, are given separately. The former two make but a small fraction of the general total; and those sportsmen who imagine that, by choosing a quicker powder, they have to allow less for the bird's flight, do not gain a vast deal in this way.

Supposing a bird to be flying across at the rate of 40 miles an hour, and 35 yards distant, the difference of time between No. 4 and Schultze (with ordinary cap) is such as to enable the bird to fly about one inch in the interval; the difference of using large cap or ordinary cap with Schultze would be 1½in.; between No. 6 and No. 4, it would be about 4½in.; and between No. 4 and No. 2 also 4½in. Thus, the greatest difference—a quarter of a yard—would be between the coarsest and the finest of the black powders, as the interval with No. 2 would allow the bird to fly 6ft. 10½in. before the shot reached it, and with No. 6 it would fly 7ft. 7½in.

We likewise add a final column showing the mean velocity of the shot for the 35 yards distance from muzzle to target.

Kind of Powder	Trigger to Cap.	Cap to Muzzle.	Muzzle to Target.	Total Time.	Mean Velocity of 35 yards.
BLACK:	Sec.	Sec.	Sec.	Sec.	Ft.sec.
No. 2	·0022	·0039	·1111	·1172	945
No. 3	·0022	·0046	·1131	·1199	928
No. 4	·0022	·0055	·1160	·1237	905
No. 6	·0022	·0063	·1216	·1301	863
SCHULTZE:					
Ordinary cap	·0022	·0076	·1154	·1252	910
Large cap	·0022	·0059	·1154	·1235	910

It will be observed that the slower the ignition of these black powders, the lower is the shot's velocity; and hence it is customary to use rather larger charges of the coarse than of the fine-grained powders. In the above experiments the charges were equal in weight; but in Messrs. Curtis and Harvey's recent pamphlet it is stated that, to obtain equal velocity with their different powders, the charges should be varied at the rate of 2grs. for each difference of size. Thus, if 3drs. were used of No. 4, there should be 2grs. more of No. 5, or 4grs. more of No. 6; or 2grs. less of No. 3, and so on. With the artillery experiments, the slow-burning powders had the largest quantity, the charges varying from 30lb. to 35lb; and increased powder causes more recoil. In the Schultze powder the slowness of ignition is compensated for in another way, viz., by the greater amount of gas eventually liberated by the combustion; and the pressure of this larger body of gas tells when the ignition is quickened. If Schultze be ignited at the same rate as No. 2 black (say, ·00158 sec. from cap to first plug), the resulting velocity for the 35 yards would be raised to near about 970 ft.sec.; but the strain would be greater even than that of No. 2. T.

TIMES OF FLIGHT OF CHARGES OF SMALL SHOT.

(*Field*, May 12, 1888; Vol. 71, p. 663.)

A FEW years ago next to nothing was known about the time taken by shot charges in traversing the space between the muzzle of a gun and a bird or target 40 yards off, or, in fact, at any other distance. The chronograph had long been at work with military weapons, but with respect to the sportsman's smoothbore everything was vague. In the absence of fact the imagination was active, and most marvellous assertions were made as to the velocity of shot charges, which by some persons were set incredibly high, and by others were made a great deal too low. The first clear light thrown upon the subject came from Mr. John Rigby, who, in a letter to the *Field* in May, 1879, after alluding to some widely different estimates that had been propounded as to the time of flight for 40 yards (such estimates varying from one-fifth to one-nineteenth of a second), went on to say: "I have ascertained the true time by the chronograph, and it varies, with the charges in general use, from one-sixth to one-seventh of a second—the latter being the time for a good 12-bore, with 3¼drs. and 1⅛oz. of No. 6 shot. These times correspond to a mean velocity of 720ft. and 840ft. per second respectively—which are of course higher than the final or striking velocity at 40 yards."

The next information with respect to chronograph records of small shot was supplied by Mr. R. W. S. Griffith, and published in the *Field* in July, 1879. These included experiments with seven sizes of shot, from No. 2 to No. 8, with variations in the loads of each, as well as of the powder charges; so that altogether there were more than fifty variations in the loading with black powder (C. & H. No. 4), besides an equal number with Schultze; and the records of three rounds with every charge were published in full in our columns, and are summarised in pp. 846 to 848 of the first volume of "The Sportsman's Gun and Rifle." What Mr. Rigby had said with respect to the mean velocities of ordinary sporting charges was virtually confirmed by Mr. Griffith's figures, although the exact charge mentioned by the former was not used in the experiments of the latter. With 3drs. of powder and 1oz. of No. 6, Mr. Griffith found the mean velocity, in a 40 yards range, to be 860 ft.sec. with C. & H. No. 4, and 858 ft.sec. with the equivalent charge (42grs.) of Schultze. With an eighth of an ounce more shot, and the same quantity of powder as before, the mean velocities fell to 827 with black and 848 with Schultze; with half a dram more powder and 1⅛oz. shot, the mean velocities rose to 909 with black and 915 with Schultze; with 3drs. and 1⅛oz., black had a slight advantage; with the same charge of

shot and half a dram more powder, Schultze was a little ahead; and so the variations went on—sometimes one and sometimes the other powder being first, but without any very material differences.

All these experiments were at the 40 yards range; and so they afforded no indication of the nature of the changes or loss of velocity at other distances, whether longer or shorter. But in February, 1883, Major McClintock published in the *Field* some tables of velocities at different distances, from 10 yards up to 60 yards, with No. 5, No. 6, and No. 8 shot. The velocities stated, however, were not direct records made by chronograph at the respective distances, but were calculated velocities based upon chronograph times taken in a 20 yards range, and worked out for other distances from the tables of Professor Bashforth. As the experiments extended over a dozen guns, which, although ostensibly of the same guage, varied greatly in their bores (whereof the measurements at many points throughout the length of the barrels were carefully taken), and as they were fired with different samples of cartridges which, though professedly containing equal charges, varied as much in their contents as the guns in their dimensions, it may readily be supposed that there were great differences in the shooting. A good deal of interest consequently attached to the comparison of the results worked out with so much care and trouble; but it has since been proved, by actual experiments, that Professor Bashforth's tables (which were intended by their author to apply only to single projectiles) cannot be relied on when applied to charges of small shot, as masses of pellets simultaneously discharged from the gun do not follow the same law as that which governs a single projectile in its isolated flight through the atmosphere. A number of pellets, propelled through the air in a combined group, encounter much less atmospheric resistance, on the average, than each pellet would incur if travelling independently; and so it unfortunately happens that Major McClintock's paper, however interesting in other respects, shows much wider differences as regards the calculated velocities at the muzzle and elsewhere than are likely to have actually occurred in practice.

Since that paper was written very extensive experiments have been carried out at twelve equi-distant ranges, from 5 yards up to 60 yards, with pellets of ten different sizes, and with various charges of powder and shot—the time of passage for each being taken by chronograph. The mean velocities for the respective charges and distances were published by Mr. Griffith in the *Field* about eighteen months ago. In the interval between then and now we have carefully compared these records; but, finding that comparisons made from the times themselves were more clear than those made from mean velocities, we reconverted those velocities into fractions of a second. In order to get them as correct as possible, we requested Mr. Griffith to compare them with the original records, so as to remove any inaccuracies arising from misprints or miscalculations; and he has not only done this, but has also tried anew any shots which seemed to indicate discrepancies. We now lay before our readers the results with 1½oz. of each of the ten sizes of shot, all fired with 3drs. of powder, or rather with its equivalent of 42grs. Schultze, from a choke-bore of 12-gauge.

1½oz. Shot of Different Sizes, with 3drs. Powder—Chronograph Times from 5 yards to 60 yards.

Nos.	1	2	3	4	5	6	7	8	9	10
Yards.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.
5	·0128	·0129	·0130	·0132	·0133	·0135	·0137	·0138	·0139	·0140
10	·0263	·0266	·0268	·0272	·0274	·0278	·0284	·0288	·0290	·0294
15	·0404	·0412	·0415	·0422	·0424	·0431	·0443	·0450	·0452	·0466
20	·0555	·0569	·0573	·0584	·0584	·0596	·0617	·0624	·0632	·0654
25	·0716	·0734	·0743	·0756	·0756	·0776	·0806	·0814	·0832	·0873
30	·0888	·0913	·0925	·0949	·0951	·0975	·1016	·1028	·1061	·1122
35	·1071	·1101	·1122	·1157	·1161	·1192	·1244	·1263	·1320	·1402
40	·1263	·1304	·1334	·1377	·1387	·1429	·1495	·1528	·1635	·1740
45	·1466	·1522	·1555	·1616	·1635	·1689	·1764	·1727	·2011	·2155
50	·1680	·1755	·1792	·1882	·1916	·1979	·2062	·2179	·2465	·2685
55	·1912	·2013	·2054	·2189	·2241	·2329	·2439	·2620	·3015	·3370
60	·2179	·2300	·2368	·2548	·2645	·2779	·2962	·3220	·3750	·4380

On dividing the number of feet, in any of these ranges, by the corresponding time given under any size of shot, the mean velocity of the shot for the given distance may easily be ascertained. Thus, with No. 6, supposing we take the 40 yards range, or 120 feet, and divide by ·1429sec., we get 840 feet per second; for ·1429sec. is almost exactly one-seventh of a second; and, as Mr. Rigby stated in the letter quoted above, that fraction of time in a 40 yards range is equivalent to 840 ft.sec. mean velocity. But Mr. Rigby further stated that "the *mean* velocity is, of course, higher than the final or *striking* velocity." How much the former is higher than the latter velocity, no chronograph record for a single distance will enable anyone to tell with small shot; but it may be found out approximately when there are a number of records, for short distances, as given in the above table; for by taking the differences between one and another, the time for each short distance is ascertained in effect, and from this time the actual velocity may be very closely estimated. Here, for example, are the times of every 5 yards with the same sizes of shot and charges as before:

1½ oz. of Shot of Different Sizes with 3drs. of Powder—Times for intervals of 5 yards.

Nos.	1	2	3	4	5	6	7	8	9	10
Yards	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.
First 5 ...	·0128	·0129	·0130	·0132	·0133	·0135	·0137	·0138	·0139	·0140
5—10 ...	·0135	·0137	·0138	·0140	·0141	·0143	·0147	·0150	·0151	·0154
10—15 ...	·0141	·0146	·0147	·0150	·0150	·0153	·0159	·0162	·0162	·0172
15—20 ...	·0151	·0157	·0158	·0162	·0160	·0165	·0174	·0174	·0180	·0188
20—25 ...	·0161	·0165	·0170	·0172	·0172	·0180	·0189	·0190	·0200	·0219
25—30 ...	·0172	·0179	·0182	·0193	·0195	·0199	·0210	·0214	·0229	·0249
30—35 ...	·0183	·0188	·0197	·0208	·0210	·0217	·0228	·0235	·0259	·0280
35—40 ...	·0192	·0203	·0212	·0220	·0226	·0237	·0251	·0265	·0315	·0338
40—45 ...	·0203	·0218	·0221	·0239	·0248	·0260	·0269	·0299	·0376	·0415
45—50 ...	·0214	·0233	·0237	·0266	·0281	·0290	·0298	·0352	·0454	·0530
50—55 ...	·0232	·0258	·0262	·0307	·0325	·0350	·0377	·0441	·0550	·0685
55—60 ...	·0267	·0287	·0314	·0359	·0404	·0450	·0523	·0600	·0735	·1010
Total...	·2179	·2300	·2368	·2548	·2645	·2779	·2962	·3220	·3750	·4380

As these figures are not merely theoretical calculations, but are the results of actual trials, they do not in every instance follow the exact arithmetical sequence which would be attained by calculations from a purely theoretical basis, though quite as regular as separate trials can be expected to give. The twelve records of time, for the twelve different distances, were not obtainable by the firing of a single cartridge; but separate cartridges had to be fired for each distance, and, in fact, several rounds were fired at each range, in order to see that the results agreed sufficiently to be relied on.

On combining the information contained in the two previous tables, one may ascertain the difference between the mean velocity for 40 yards, or other distance, and the striking velocity of the pellets at the end of such range. The "estimated actual velocity," as given below, is based on the average velocity for 5 yards before and 5 yards after the actual distance. Professor Bashforth has shown that, with single projectiles, the mean velocity for a given short range may be taken as the actual velocity at the mid-point of the range; and that proves practically correct with rifle bullets up to 50 or 100 yards or more. With small shot, however, it is not so exact, except at much shorter distances; but for the range of 5 yards any variations must be so small as to be immaterial. Thus, to take an example in point, the chronograph time for 10 yards with No. 6 shot gave a mean velocity of 1079 f.s., while the calculation of actual velocity at half the distance is 1080 f.s., as will be seen by reference to the first and third columns of the ensuing table.

Mean and Actual Velocities with 1½oz. No. 6 and 3drs. Powder.

Mean velocities for different full ranges. Range.	Feet per second.	Mean velocities for separate 5 yards. Yards.	Feet per second.	Estimated actual velocities. Feet per second.
5 yards	1111	First 5	1111	(1111 at 2½ yards.)
10 ,, ...	1079	5 — 10	1049	1080 at 5 yards.
15 ,, ...	1044	10 — 15	980	1015 at 10 yards.
20 ,, ...	1007	15 — 20	909	871 at 20 yards.
25 ,, ...	966	20 — 25	833	
30 ,, ...	923	25 — 30	754	723 at 30 yards.
35 ,, ...	881	30 — 35	691	
40 ,, ...	840	35 — 40	633	605 at 40 yards.
45 ,, ...	800	40 — 45	577	
50 ,, ...	758	45 — 50	517	473 at 50 yards.
55 ,, ...	708	50 — 55	429	
60 ,, ...	647	55 — 60	333	

One may see here that, when an opinion is formed solely on the chronographic record of velocity for a 40 yards range, it affords very little idea of the ultimate striking force of the pellets, because it merely gives the average speed for the entire distance; and a high velocity at the muzzle tends to raise the average, although other influences may lessen the penetrative power at the end of the range. The mean velocity for 40 yards (which is the record usually given) happens in this instance to be 840 feet a second, whereas the striking or remaining velocity at the end of the range is about 230 feet less.

But this striking velocity never is stated in the published results of chronographic experiments, because the chronograph itself will not show it from the records of any one distance; and it is possible for one record of average speed for a given range to be higher than another, when two guns are fired, or two methods of loading adopted, and yet the charge that makes the slower average may have the higher velocity or killing power at the finish. It is only when one gets such an abundance of material as is supplied by the elaborate experiments of Mr. Griffith, that one can trace out such facts to their legitimate conclusion.

And, even with all this material, one cannot say with certainty what is the velocity with which the pellets commence their journey, or that at which they finish the full distance of the last range for which the chronographic record is taken. Thus, the velocity at the muzzle, and at 60 yards, cannot be calculated with accuracy from the above data—they can only be guessed at; and here the muzzle velocity may be estimated, in round numbers, as about 1140 or 1150 ft sec. With the same charge of powder and only an ounce of shot, the muzzle velocity would be probably raised by about 40 or 50 feet; but the effect of this and other alterations of charges at different ranges must be left for future consideration. T.

SHOT VELOCITIES AND FORCE-GAUGE RECORDS.

(*Field*, June 2, 1888; Vol. 71, p. 801.)

We pointed out in our last article (reprinted above) that chronograph records, as ordinarily set forth, afford but little idea of the striking force of the pellets of shot guns, because the velocities that are stated represent merely the mean speed for the entire distance, and give no indication of the amount of velocity still retained by the pellets at the time when they hit the target; and yet this remaining velocity is the real measure of penetration. We likewise showed, however, that when there were successive chronographic records for short distances (such as those made in the elaborate experiments carried out by Mr. Griffith), the remaining velocity at different points may be very closely estimated—so closely, indeed, that the successive estimates may be accepted as practically correct representations of the actual velocities.

From the last table that was given (opposite) it will be seen that where a charge of No. 6 shot, fired from Mr. Griffith's 12-gauge choke-bore, showed an average speed of 840 ft.sec. for a range of 40 yards, the velocity that remained in the pellets at the end of that distance was 605. In other cases, however, the remaining velocity at 40 yards may be the same (605), and the chronographic *mean* velocity for the whole range may be higher or lower than 840. In short, there is some degree of resemblance between the velocities of shot charges and the speed of railway trains. Two trains may each run 40 miles in an hour, and yet travel at very different rates for the last mile; or they may run the last mile in equal times, and yet be more or less than an hour in going the full distance of 40 miles, and thus, in other words, may have a different "mean velocity."

Many sportsmen, and many gunmakers likewise, seem to be impressed with the idea that by increasing the charge of powder the penetrative force of the shot must necessarily be increased. But it is obvious that our correspondent "20,000 Shots" is not imbued with such a fallacy; for he said, many years ago, if we remember rightly, that with all guns there is a point beyond which the charge cannot be increased with advantage; or, as he expressed it a few weeks ago, with respect to a gun loaded to its full extent, "if any addition be made to the weight of powder or shot, the shooting will fall off in pattern or force, often in both." And if it be true—as we are convinced it is—that the penetrative force of a shot charge may under certain conditions be diminished by an increase of powder, we must also have the corollary that there are circumstances under which the striking force of charges of loose shot (not isolated bullets) may be increased by a reduction of powder. Of the truth of this we are also convinced. And yet the larger charge of powder doubtless gives a higher muzzle velocity, although it may not show greater penetration at the end of 40 yards. The muzzle velocity will depend upon the proportion of the charge used in the gun; the penetrative power, or velocity remaining in the pellets at the end of the range, is dependent mainly upon the skill of the borer of the gun, and the care bestowed upon the loading of the cartridges.

If the pellets are made to keep together in a compact mass, they retain a much larger proportion of their original velocity than an equal number of pellets scattered at random; and thus a charge which had but a comparatively low initial speed may eventually have higher velocity than a similar charge which received greater propulsion at the onset. An illustration of this may be found with a charge of shot confined in a wire cartridge. This charge, if fired from a cylinder gun with 2½drs. of powder, would ultimately have a higher velocity than a similar charge, unconfined, but propelled with half a dram or a dram more powder. Yet the muzzle velocity of the latter would be much the higher of the two, and the chronograph would, up to a certain point, show greater mean velocity. In a less degree the same thing would occur with the concentrators introduced by Mr. Charles Lancaster about twenty years ago, but now virtually superseded by the choke-bore, by which a somewhat similar concentration is effected in a different way. No increase of initial speed is given to the charge, either by the wire cartridge, the concentrator, or the choke-bore—they probably diminish the muzzle velocity to some extent, owing to increased friction in the barrel; but they effect the r purpose of maintaining a higher speed by the simple process of keeping the pellets in a mass, and thus enabling them to pass through the air for a time in a manner that bears some degree of resemblance to a solid ball—which, as everyone knows, retains its original velocity in much greater degree than the loose pellets of small shot.

Hence, if the conditions of the gun and its loading are such that an increase of powder can be given to the charge without causing the pellets to scatter more than before, then there will be an addition to the striking force at the end of the range, as well as to the muzzle velocity; and if, on the other hand, the conditions are such, that a reduction of the powder charge, or an increase of the shot, so steadies the explosive effect that the pellets travel in a more compact mass, then the ultimate result may be greater striking force at the end of the range, although the immediate effect would be a reduction of velocity at the muzzle.

In illustration of the differences of effect produced by the concentration of the charge from a choke-bored gun as compared with that from a cylinder, a few particulars may be extracted from experiments carried out by Mr. Griffith. A good choke-bore and a good cylinder gun were fired with cartridges loaded exactly alike. As may naturally be expected, all the pellets from each of the guns were put into the 30in. circle at a distance of 10 yards; but even in that short range there was a considerable difference in the spread of the charge, as the diameter of the pattern from the cylinder was about 18in., as compared with 9in. for the choke-bore. At greater distances the distribution of the pellets from the respective guns was as follows:

DISTRIBUTION OF PELLETS BY CHOKE-BORE AND CYLINDER.

Choke-bore:	20yds.	30yds.	40yds.	50yds.
In 2½ft. circle	304	278	233	160
From 2½ft. to 4ft.	0	24	65	90
Outside 4ft. circle	6	2	6	54
Total charge	304	304	304	304
Cylinder:				
In 2½ft. circle	264	172	130	76
From 2½ft. to 4ft.	38	46	103	86
Outside 4ft. circle	2	42	71	142
Total charge	304	304	304	304

The charge which was most scattered suffered most in loss of velocity. The respective times of the first and the last pellets of the charges at the different distances were as follows:

TIMES OF FIRST AND LAST PELLETS OF CHARGE.

Choke-bore:	10yds. Sec.	20yds. Sec.	30yds. Sec.	40yds. Sec.	50yds. Sec.
First pellets	·0265	·0559	·0923	·1357	·1871
Last ,,	·0335	·0704	·1143	·1717	·2331
Difference	·0070	·0145	·0220	·0360	·0460
Cylinder:					
First pellets	·0266	·0565	·0935	·1380	·1915
Last ,,	·0383	·0787	·1275	·1870	·2485
Difference	·0117	·0222	·0340	·0490	·0570

It will be observed that the time for the first 10 yards with the leading pellets of the choke-bore was ·0265sec., and with those of the cylinder ·0266sec., or nearly identical; and it is probable that the latter left the muzzle with rather the higher speed, as the constriction of the choke would be likely to give a momentary check. But a conspicuous difference in the effect of the concentration of the charge will be seen by the way in which the last pellets from the cylinder lag behind the first, as compared with the choke, even at 10 yards, and how both first and last pellets drop off as the distance increases. At 30 yards, the mean velocity of the first pellets from the choke-bore is

976 f.s., in comparison with 963 from the cylinder—a difference of less than 2 per cent.; but the mean velocity of the last ten pellets is 788 with the choke, as compared with 706 with the cylinder—the falling off with the latter being about 30 per cent., in contradistinction to 20 per cent. with the choke-bore. If such, then, be the result with two equally well-loaded guns, what must be the consequence when guns are loaded with bad wads and unsuitable charges, which cause the shot to scatter at random? As soon as individual pellets break away from the main body of the charge, they instantly encounter greater atmospheric resistance, and are left in the rear by the compact nucleus; and the larger and more compact the nucleus, the less is the retardation it undergoes. If it were not for this difference of atmospheric resistance, the shot charge would be retarded uniformly, and pellets having the same muzzle velocity would strike the target at the same time, instead of straggling in, some of them many yards in the rear of others.

The experiments of Mr. Griffith which have just been quoted, besides indicating the relative velocities of the first and last pellets, also show the comparative speed of other portions of the same charge; and the facts stated are very useful in enabling one to trace how it is that compact but comparatively slow-moving masses of shot may overtake faster pellets; or, to put it more exactly, they indicate the gradual dwindling away of the speed of a scattered charge, until the disunited pellets, losing their original advantage, eventually succumb to those which practically exemplify the old adage that "union is strength." The following table will show how the first cluster of pellets from the cylinder differs in time as compared with the first from the choke-bore (with 3drs. of powder and 1⅛oz. of No. 6 shot); and how the second batches of pellets—comprising 25 per cent. of the whole pattern—likewise differ, the cylinder times growing longer and longer in comparison with those of the choke. Thus, the time of the leading pellets from both is nearly the same for the first 10 yards, but very different between 40 and 50. Again, the time for the *second* batch of the choke-bore, from 40 to 50 yards, is virtually the same as for the *fastest* cylinder pellets; yet the latter did the first 10 yards in 4 per cent. less time.

For further comparison we add the times for a charge of 2½drs. of powder and 1oz. of shot, from the same choke-bore gun. The original velocity is low, but the charge keeps compact, and retains its speed better than the faster pellets with the larger quantity of powder; and, although 2½drs. cannot be expected to equal 3drs. in the same gun, the small charge with the choke-bore makes as good time as the larger with the cylinder after the pellets have gone beyond 40 yards.

	Fastest pellets, with 3drs.		Second Batch.		Small charge of Powder. (2½drs.)
	Choke-bore	Cylinder.	Choke-bore.	Cylinder.	
Yards.	Sec.	Sec.	Sec.	Sec.	Sec.
First 10	·0265	·0266	·0275	·0281	·0311
10—20	·0294	·0299	·0304	·0314	·0347
20—30	·0364	·0370	·0379	·0390	·0408
30—40	·0434	·0445	·0454	·0475	·0476
40—50	·0514	·0535	·0536	·0557	·0555

Of course, when a charge of shot strikes the target, the pellets with different velocities follow one after another, and the force-gauge record must include all that hit the 10in. plate, whether they are fast or slow; but the chronograph takes only the first portion of the charge, and, whether this portion be 5 per cent. or 25 per cent. of the whole, the chronographic record is not affected by any slower pellets of the rest of the charge. But Mr. Griffith's revolving target records (page 50) state the average velocity of the whole pattern as well as separate portions; and the following table will show how this average compares with the first and last pellets of different charges. We give likewise the mean velocities for 40 yards, as directly obtained from the chronograph times; and it will at once be seen how far such records are from indicating the force that remains in the pellets at the time when they strike the object fired at.

Time and Mean Velocity for 40 Yards.			Remaining Velocity at 40 Yards.		
Charge and Gun	Time Sec.	Mean Velocity.	Fastest Pellets.	Slowest Pellets.	Average of the whole.
3½drs. (choke-bore)...	·1290	= 938	661	540	618
3drs. (ditto) ...	·1357	= 884	633	505	580
3drs (cylinder).....	·1389	= 870	612	496	549
2½drs. (choke-bore)...	·1542	= 778	585	... no record ...	—

Strictly speaking, however, the 2½drs. record (585 f.s.) was not the velocity of the "fastest pellets," for with this charge they were not taken separately; and, if these fastest pellets were allowed for, the record would probably be raised to about 600, or perhaps a trifle over. Without, however, making any such allowance, it will be observed that the remaining or striking velocity of the 2½drs. charge falls only 193 f.s. below the mean velocity; whereas the 3drs. (choke) falls off 251, and the same charge in the cylinder falls off 258. It is obvious, therefore, that a comparison of the chronographic records of mean velocity alone would place the 2½drs. at a great disadvantage as regards an estimation of the relative striking force of the different charges of shot.

It must not be supposed, however, from what is here said, that we are advocating the adoption of very small charges of powder. We merely endeavour to point out that a reduction of the powder charge does not lessen the "remaining velocity" or striking force of the shot to so great an extent as most people imagine; and that the ordinary chronographic records give no indication of the amount of velocity really remaining at the end of the range. What the ordinary chronograph records do indicate is the time of flight, with its corresponding "mean velocity" for the whole distance, as shown in the first half of the last table. These figures show, clearly enough, that the total time for 40 yards is much longer with a small charge than with a large charge of powder; and consequently, if anyone proposes to indulge in the use of very small charges, he should be prepared to aim further in front of his game, or else he will be likely to miss it.

Having thus shown how the remaining velocity or striking force of shot charges may be traced out where there are chronographic records for short distances, such as have been supplied by Mr. Griffith, we will now briefly indicate the way in which these velocities correspond with the records supplied by Mr. Walsh's force-gauge. In a paper on the "Velocity and Energy of Small Shot," read by Mr. John Rigby, in February 1883, and published in the "Scientific Proceedings of the Royal Dublin Society," the author said:

> In 1878, Mr. J. H. Walsh, the ingenious editor of the *Field* newspaper, dissatisfied with the tests then in use, devised a kind of recoiling target, which he named a "force gauge," for the purpose of measuring the force with which the pellets in a charge of shot struck the mark at a certain distance. Up to that time very vague ideas were held as to the actual velocity of the charge propelled from shot guns.

Mr. Rigby then proceeded to describe some chronographic experiments which he himself carried out in 1879, of which he gave the mean velocities, as well as the results of calculations he had made to estimate the muzzle velocity and the remaining velocity of the pellets at 40 yards; and with respect to some shot (291 pellets to the ounce) on which he had based his calculation, he remarked: "The velocity of 634 f.s., at 40 yards, was found to agree closely with the results of a calculation [270 pellets to the ounce] made from the observed motion of the *Field* force-gauge when struck by the shot at that distance."

The method here alluded to, of calculating from the observed motion of the force-gauge, was described in the *Field* shortly after the instrument was invented, and simply amounts to this—that if the record of "force per pellet" be multiplied by the number of pellets in the ounce of shot, the product will represent the velocity with which the pellets strike the force-gauge. Thus, if a charge of No. 6 shot makes the record of 2·00, multiply this by 270, and the corresponding velocity is 540 f.s.; or, if a charge of No. 5 makes a record of 2·50, multiply this by 218 pellets, and the velocity shown is 545 f.s.

Let us, then, turn this process to account in connection with experiments to which we have already called attention; and, in order to bring the remaining velocities, as obtained from chronograph records of very short distances, into juxtaposition with those obtained from force-gauge records, we give both from different sets of experiments, converting velocity into force-record, and *vice versâ*, to show how they compare.

Records of 12-bore Guns, with Different Charges of Powder.

All 1⅛oz. of No. 6 Shot.	3drs. Velocity. Ft.-sec.	3drs. Force. Record.	3½drs. Velocity Ft.-sec.	3½drs. Force Record.
Mr. Griffith's experiments, with Schultze, taking about 25 per cent. of pattern (choke-bore)	605*	= 2·24	645*	= 2.39
Mr. Griffith's experiments, with Schultze, giving average of whole pattern (choke-bore).....	580*	= 2·15	618*	= 2·29
Ditto, with cylinder gun.....	549*	= 2·03	—	—
Mr. Jones's recent force-gauge experiments, with				
J.B. powder (choke-bore)	586	= 2·17	626	= 3·32*
E.C. powder (choke-bore)	569	= 2·22*	—	—
C. & H. No. 4 (choke-bore).....	572	= 2·12*	—	—
" " (cylinder, paper case)..	516	= 1·91*	—	—
" " (ditto, "perfect" case)	521	= 1·93	—	—

SMALL-BORE (28 "PERFECT") WITH DIFFERENT SIZES OF SHOT.

	No. 6.			No. 5.		
1¾drs. C. & H. No. 4, with 1oz. shot	499	=	1·81*	536	=	2·46*
ditto with ¾oz. shot	526	=	1·95*	591	=	2·71*
Same gun and 1oz. charge, but different wads	510	=	1·89*	567	=	2·60*

We have indicated by an asterisk (*) what may be termed the fundamental data. Thus, the force-records so marked are directly obtained from Mr. Jones's score-sheets, whereas the corresponding velocities are calculated from these force-records, by multiplying the respective numbers by 270. On the other hand, the velocities given in connection with Mr. Griffith's experiments are derived from the times which he has recorded; while the corresponding force-records are calculated by dividing his velocities by 270. With No. 5 shot, the force record is, of course, multiplied by 218.

As the *Field* gun trial of 1879 (the only one carried out with the force-gauge) has often been alluded to as showing that that apparatus favoured low charges, we append a list of the highest records made with the various charges used, and, as in the previous table, give the remaining velocity calculated from the force-record, which, however, it is not necessary here to mark with an asterisk, all being on the same footing.

12-BORES, WITH 1¼OZ.				16-BORES, WITH 1OZ.				20-BORES, WITH 1OZ.			
Drs.	Velocity.		Force.	Drs.	Velocity.		Force.	Drs.	Velocity.		Force.
3¼	613	=	2·29	3¼	599	=	2·22	2¾	599	=	2·22
3¼	645	=	2·39	3	589	=	2·18	2½	564	=	2·09
3¼	634	=	2·31†	2¾	602	=	2·23	2¼	621	=	2·30
3⅛	605	=	2·24	2½	567	=	2·10	2	562	=	2·08
3	599	=	2·22	2¼	610	=	2·26	1¾	553	=	2·05
	1OZ. SHOT.				⅞OZ. SHOT.				⅞OZ. SHOT.		
3	578	=	2·14	2½	605	=	2·24†	2	605	=	2·24†

The winning gun in each class is marked with a dagger (†); and, in order to include the 12-bore winner, two records with 3¼drs. are given, as another gun showed higher force. It will be observed that in the 16-bore and 20-bore classes the winners were not guns that used the smallest charge of powder, but those which used the smallest charge of shot; and it must be borne in mind that the awards were influenced to a considerable extent by the penalties for recoil, &c., which were incurred in much greater degree by those employing heavy loads.

In conclusion, we may say that, even though there may have been defects in the force-gauge at the 1879 trial, they have been lessened by subsequent improvements; and the above tables show that its records of the average striking force of shot charges, obtained with little expenditure of money or time, compare very closely with the results ascertained by the employment of far more costly apparatus, requiring much skill, time, and patience to work out satisfactorily. And we cannot but express our indebtedness to Mr. Griffith for the great amount of information which he has enabled us to lay before our readers, and without which it would have been impossible to trace, with any degree of certainty, the difference which exists between the velocity of pellets when they actually strike the target, or game fired at, and the mean velocity ordinarily set forth as the record of the chronograph. T.

INFLUENCE OF GUNBARRELS ON THE SHOOTING QUALITIES OF POWDERS.

(*Field*, June 22, 1889; vol. 73, p. 883.)

SEVERAL months ago we resolved to carry out a series of experiments of which we hope to say more on a future occasion; but at present we need not trouble our readers with details further than to state that, at a preliminary trial of some guns and powders to be used in those experiments, results were obtained which have a bearing on a discussion in our columns with respect to nitro powders.

The experiments, it will be seen, were made with seven kinds of gunpowder, three being nitro compounds, three being black powders of different makers, and the seventh being the brown powder made by Messrs. Curtis and Harvey. Three guns were used, two being single barrels (one choke-bore and the other cylinder bored), and the third a double gun with choked and cylinder barrels; so that there were two cylinder barrels intended to give as nearly as possible the same results, and two choked barrels also intended to be equal. The barrels were all of 12 gauge, and 30in. long. For these four barrels the cartridges were loaded alike—*i.e.*, two dozen cartridges of Schultze being in readiness, six were taken indiscriminately for use in each of the four barrels; and the same with every other kind of powder. When full particulars of the experiments are published we shall give the details of loading; but they may be dispensed with here, the object being merely to show the variation produced by using similar cartridges in different barrels. We may state, however, that the sample of shot used in these preliminary experiments was not up to the full regulation weight of No. 6 shot. The charge (304 pellets) was counted with the counting trowel, but about ten more pellets would be required to make up the full 1¼oz. by weight; and consequently the force-record is not so high as it would have been if the pellets had been up to the proper standard.

The first table given represents the results obtained with the single-barrel guns, each set of figures being the mean of six shots; while the average stated at the foot of the columns is the mean of the forty-two shots fired with the seven different explosives. The powders are arranged in the order of merit, or total obtained by the ordinary method of adding pattern to force and omitting the decimal point.

SINGLE-BARREL GUNS.

CYLINDER.					CHOKE-BORE.				
	Pattern.		Force.	Total.		Pattern.		Force.	Total.
No. 2 Blk.	126	...	1·94	320	E.C.	208	...	2·01	409
No. 6 Blk.	135	...	1·79	314	Schultze	194	...	1·87	381
Schultze	120	...	1·87	307	J.B.	184	...	1·90	374
Brown	116	...	1·78	294	No. 4 Blk.	188	...	1·81	369
E.C.	124	...	1·70	294	Brown	167	...	1·91	358
J.B.	121	...	1·72	293	No. 2 Blk.	160	...	1·86	346
No. 4 Blk.	109	...	1·71	280	No 6 Blk.	177	...	1·69	346
Average	122	...	1·79	301	Average	183	...	1·86	369

On comparing the two halves of the table, it will be seen how differently the same batch of cartridges behaved in the two barrels. E.C. showed the highest force of the lot in the choked barrel, and the lowest of the lot in the cylinder; Schultze showed equal force with both barrels; and the two black powders which come first on the list with the cylinder are last on the list with the choke.

In the next table, which relates to the double-barrel gun, the results are much more regular, as the first three powders with the one barrel occupy the same relative positions with the other; but it is curious that, with the cylinder, E.C. again made the lowest force-record of the whole series, although with the choke it was one of the highest.

DOUBLE-BARREL GUN.

CYLINDER.					CHOKE-BORE.				
	Pattern.		Force.	Total.		Pattern.		Force.	Total
Schultze	149	...	1·78	327	Schultze	225	...	1·97	...
J.B.	131	...	1.82	313	J.B.	220	...	1·98	...
E.C.	133	...	1·61	294	E.C.	217	...	1·95	...
Brown	125	...	1·69	294	No. 4 Blk.	166	...	1·82	348
No. 2 Blk.	121	...	1·71	292	No. 6 Blk.	168	...	1·78	346
No. 6 Blk.	126	...	1·66	292	Brown	167	...	1·78	345
No. 4 Blk.	117	...	1·74	291	No. 2 Blk.	145	...	1·75	320
Average	129	...	1·72	301	Average	187	...	1·86	373

As it is not easy to compare the variations in pattern and force of the same powder in different barrels, when they are scattered apart as in the previous tables, we here bring them together; the first two columns represent the cylinder records, and the next two those of the choked barrels. It is noticeable that, with some of the black powders, the force-records are higher in the cylinder barrels than in the choke-bores.

	PATTERN.			FORCE.		
	Cylinder.	Choke.	Aver.	Cylinder.	Choke.	Aver.
Schultze	120 149	194 225	= 172	1·87 1·78	1·87 1·97	= 1·87
E.C.	124 133	208 217	= 170	1·72 1·82	1·90 1·98	= 1·85
J.B.	121 131	184 220	= 164	1·70 1·61	2·01 1·95	= 1·82
No. 6	135 126	177 168	= 151	1·94 1·71	1·86 1·75	= 1·81
No. 4	109 117	188 166	= 145	Brown... 1·78 1·69	1·91 1·78	= 1·79
Brown	116 125	167 167	= 144	No. 4	1·71 1·74	1·81 1·83	= 1·77
No. 2	126 121	160 145	= 138	No. 6	1·79 1·66	1·69 1·78	= 1·73

Now, had the experiments with these powders been carried out in one barrel only, instead of in four, how different a conclusion might have been formed as to the respective merits of the powders, according to which of the barrels happened to be used. Hence a very satisfactory reason may be found for some persons using a nitro-compound in the first barrel and black powder in the second, and for others using a nitro-compound in both barrels; and (though it is, of course, much less common) we have heard of one nitro-compound being used

in the right barrel and a different one in the left. Generally speaking, however, people are much too apt to imitate one another: and so we see A. B. adopting a particular kind of powder or method of loading merely because it is adopted by Y. Z., who is a good shot; but it may happen that what does best in Y. Z.'s gun does worst in that of A.B. Last week a correspondent suggested that we should carry out a series of experiments with the full charges used for pigeon shooting, in order to determine which is the best powder for that purpose; but we doubted whether any practical advantage would ensue, and we accordingly advised him to try the results with his own gun, for what would suit one weapon would not necessarily be best for another. It is not desirable to draw general conclusions from isolated premises; and we accordingly advise our readers, as we have done before, to try different explosives in their guns, and adopt that kind which gives them the best results. When they have come to a conclusion as to what is best, let them not make any variation without good cause; for if they change their wads a very different effect may be produced; and if they adopt the cartridge cases of a different maker, the alteration in strength of the cap may be an advantage with one nitro-compound, but cause a considerable deterioration with another. P.—T.

USE OF "PERFECT" AND PAPER CASES IN THE SAME GUN.

(*Field*, Oct. 17, 1891; Vol. 78, p. 595.)

QUESTIONS arise from time to time with reference to the employment of brass "perfect" cases in guns that have been bored for ordinary paper shells. As our readers generally are aware, the substitution of thin brass for thick paper, in shells of the same external diameter, is equivalent to an enlargement of the internal diameter; so that a No. 12 "perfect" case is not 12-bore in gauge, but 10-bore wads have to be used in the loading. Questions not unnaturally arise, therefore, as to the effects produced by forcing the shot-charge and wads of 10-gauge through a barrel which is two sizes smaller. Here is a letter we have received from St. Petersburg, asking for information on the subject:

SIR,—I should feel much obliged if you could enlighten me on the following:

Do you consider that Kynoch's brass cartridge cases (No. 10 wads) are as good for an ordinary bore 1 gun as paper? I have tried some—owing to the tremendous prices charged here for cartridge cases—and they seem to act well. At the same time, it seems to me that the big wads must require some amount of force to be expended on them alone; which should, logically, increase recoil, and damage shot velocity and penetration.

St. Petersburg, Oct. 8, 1891. BEDOUIN.

Until recently we were not in possession of definite information wherewith to meet inquiries of this kind; but in the course of the past summer we carried out some experiments which will enable us to do so, and we now proceed to state the results.

We find, in the first place, that the large amount of frictional resistance produced by forcing the charge and wads of 10-gauge through a barrel of narrower dimensions has the effect of considerably reducing the muzzle velocity of the shot, and also of lessening the amount of recoil—though the latter diminishes in a smaller ratio than the speed.

In order that it may be seen that the conclusions here arrived at do not depend upon the exceptional results of one or two chance shots, we give records of the individual rounds, and, for facility of comparison, arrange them in order of velocity. The charge used throughout was 1¼oz. of No. 6 shot, with 3drs. of black or 42grs. of nitro powder, fired from the same barrel (chambered for paper cases, without any alteration to adapt it to the thin brass cases), and under exactly the same conditions, except that the paper cases had the usual wads for a 12-bore and the brass cases had 10-gauge wads. The paper cases as well as the "perfects" were of Kynoch's make, so both would have caps of the same strength. The records were as follows:

BLACK POWDER (C. & H. No. 4).

Cartridges.	Velocity and Recoil.					Averages.
Paper (12-bore)—Velocity ...	1069	1100	1103	1103	1122	1125=1107 ft.sec.
" " *Recoil*	*30·6*	*30·6*	*30·9*	*32·1*	*30·6*	*31·1=30·9 ft.lb.*
Perfect (10-bore)—Velocity.	912	935	947	951	955	955= 943 ft.sec.
" " *Recoil* ...	*27·4*	*27·7*	*27·7*	*27·9*	*28·2*	*28·6=27·9 ft.lb.*

SCHULTZE POWDER.

Paper (12-bore)—Velocity ...	1095	1108	1114	1120	1122	1125=1114 ft.sec.
" " *Recoil*	*27·4*	*27·1*	*27·3*	*27·3*	*27·0*	*27·4=27·3 ft.lb.*
Perfect (10-bore)—Velocity.	970	972	976	984	993	997= 982 ft.sec.
" " *Recoil* ...	*22·7*	*22·2*	*23·3*	*23·3*	*23·6*	*24·8=23·3 ft.lb.*

The velocities here mentioned represent the mean speed of the shot for a distance of five yards from the muzzle of the gun to the electric screen of the chronograph; and in order to obtain an estimate of the muzzle velocity (which cannot be exactly calculated with shot-charges in the same manner as with bullets) we add 2 per cent. to the mean speed in each case, which gives a close approximation to what the velocity of the charge must have been on making its exit from the muzzle.

On this basis, the muzzle velocity with black powder averaged 1129 f.s. with the 12-bore paper cases, but fell to 962 f.s. when the brass cases and 10-bore wads were used. With Schultze the muzzle velocity with paper cases was 1136 f.s., and with the brass cases and large wads it fell to 1002 f.s.; a large reduction, though not so much as with the black powder.

On records of strain in the barrel being taken by means of the crusher-gauge, the pressure per square inch in the 10-bore was found to be considerably lower than in the 12-bore cartridge. As is ordinarily the case, when the same charges are used in barrels of different gauge, the greatest pressure occurs in the smallest gauge. At the first plug (situate 1 inch from the breech) and at the second plug (2½in. from the breech, and consequently at the end of the cartridge case) the pressure per square inch with black powder was 12 per cent. lower in the brass case; but as the wads in the paper shell were 12 per cent. smaller than those in the brass cases, the one counterbalanced the other, and the actual pressure on the shot-charge was almost identically the same. It was not so, however, with the nitro-compound. Being slower in action than the black explosive, it must have gradually prised open the crimped end of the large case before much of the powder was burnt, and so the pressure recorded was less than half of that exhibited by the same powder in the paper shell. At the second plug (2½in.) the deficiency was reduced to one-third; and at the third plug (6in. from the breech, and consequently well within the narrow part of the barrel) Schultze was exhibiting a little more pressure than the black powder—the extra resistence of the tight wads and charge apparently developing increased force from the nitro-compound. It would be likely, moreover, to maintain a greater pressure than black throughout the rest of the barrel; and this would account for the shot having greater velocity at the muzzle.

It was stated in the *Field*, several years ago, as the result of experiments carried out by Mr. R. W. S. Griffith, that a dead weight pressure of about 20lb. (varying a little more or less, whether the gun was a cylinder or a chokebore) was required to force a charge of 1¼oz. of No. 6 shot and wads through a 12-bore barrel. From a calculation we have made as to the cause of the reduction of velocity above mentioned, it would appear that the driving of the same charge from a 10-gauge cartridge through a 12-bore barrel increases the resistance by more than 170lb.; so that the friction appears to have a tenfold increase—from about 20lb. to nearly 200lb.

Now comes another aspect of the question; and that is with respect to the performance at the target. We have at various times had occasion to remark that the velocity of a charge of small shot, at the instant it quits the muzzle, is by no means a good criterion for forming a satisfactory estimate of the performance of the gun at a distance of 40 yards. We are not going to say that the slower charge did best at the target; for such was not the fact. Chronographic records showed that the charges from paper cases gave higher mean velocity for the 40 yards range, and the force-gauge showed that the same charges gave higher striking force at the end of the distance; but the differences were very much less marked than those of the muzzle velocities. The higher the speed of the shot the larger is the proportion of velocity lost in passing through the atmosphere; and the charges that had an advantage of about 150 f.s. when the charge left the gun, scarcely retained one-fourth of that advantage when the shot struck the target at the end of 40 yards. The average patterns, however, with the two kinds of cartridges did not vary very much, as will be seen by the following records, in which both chokebore and cylinder have an opportunity of showing their deeds:

CHOKEBORE GUN.

BLACK POWDER WITH PAPER CASE.

Pattern (30in. circle.)	On 10-inch Plate. Force on Gauge.	Number of Pellets.	Force per Pellet.	Recoil. Ft. lb.
207	69	+ 35 =	1·97	30·6
236	137	+ 60 =	2·28	31·1
180	60	+ 30 =	2·00	30·9
173	48	+ 23 =	2·09	30·9
210	97	+ 48 =	2·02	31·1
220	90	+ 44 =	2·05	30·9
204 ... Averages.....			2·07	30·9

BLACK POWDER WITH "PERFECT" CASE.

Pattern (30in. circle.)	On 10-inch Plate. Force on Gauge.	Number of Pellets.	Force per Pellet.	Recoil. Ft. lb.
170	67	+ 39 =	1·72	27·4
167	80	+ 42 =	1·90	27·7
174	50	+ 25 =	2·00	28·9
200	88	+ 48 =	1·83	28·4
195	72	+ 38 =	1·89	28·4
181	70	+ 34 =	2·06	28·2
181 ... Averages.....			1·90	28·2

SCHULTZE POWDER WITH PAPER CASE.

ON 10-INCH PLATE.

PATTERN. (30in. circle.)	Force on Gauge.	Number of Pellets.	Force per Pellet.	RECOIL. Ft. lb.
210	72	+ 35 =	2·06	25·5
197	82	+ 40 =	2·05	26·0
206	92	+ 46 =	2·00	25·9
175	67	+ 32 =	2·09	25·7
187	82	+ 40 =	2·05	25·7
182	80	+ 38 =	2·11	25·5
193	Averages		2·06	25·7

SCHULTZE POWDER WITH "PERFECT" CASE.

ON 10-INCH PLATE.

PATTERN. (30in. circle.)	Force on Gauge.	Number of Pellets.	Force per Pellet.	RECOIL. Ft. lb.
206	85	+ 43 =	1·98	23·3
188	71	+ 36 =	1·97	23·0
204	73	+ 38 =	1·92	21·9
176	62	+ 30 =	2·07	24·1
188	85	+ 42 =	2·02	23·8
180	81	+ 40 =	2·02	23·3
190	Averages		1·99	23·2

Here it will be observed that there was very little difference in the patterns made by Schultze with the two kinds of cases and wads; but with black powder there was wider variation. In force there was greater falling off with black powder, with which there had also been greater diminution in muzzle velocity.

With the cylinder barrel, owing to an oversight, only the records with the "perfect" case were taken. The most noticeable feature is the small pattern; it is much less than that ordinarily given by the same gun, which with paper cases usually gives a pattern of about 120.

CYLINDER BARREL.

BLACK POWDER WITH "PERFECT" CASE.

ON 10-INCH PLATE.

PATTERN. (30in. circle.)	Force on Gauge.	Number of Pellets.	Force per Pellet.	RECOIL. Ft. lb.
96	35	+ 18 =	1·94	28·0
95	30	+ 16 =	1·87	27·7
84	41	+ 20 =	2·05	28·7
127	24	+ 12 =	2·00	27·7
100	34	+ 18 =	1·89	27·9
93	24	+ 13 =	1·85	27·7
99	Averages		1·93	27·9

SCHULTZE POWDER WITH "PERFECT" CASE.

ON 10-INCH PLATE.

PATTERN. (30in. circle.)	Force on Gauge.	Number of Pellets.	Force per Pellet.	RECOIL. Ft. lb.
86	35	+ 19 =	1·84	21·9
120	38	+ 20 =	1·90	21·2
92	32	+ 17 =	1·88	23·0
88	30	+ 15 =	2·00	22·0
110	30	+ 17 =	1·76	23·3
101	26	+ 14 =	1·86	22·3
99	Averages		1·87	22·3

Since the above was put into type it has occurred to us to examine some records of shot velocities made by Mr. R. W. S. Griffith several years ago, and to compare them with those recently made by ourselves. We find that Mr. Griffith's record for 5 yards, obtained with 42grs. Schultze and 1⅛oz. No. 6 shot, runs very close to ours obtained with the same charge and the paper case; and that Mr. Griffith's record with 35grs. (equivalent to 2½drs.) of Schultze and 1oz. shot also runs very close with our record obtained with the "perfect" case and 10-bore wads. The figures are as follows:

MR. GRIFFITH'S RECORDS FOR FIVE YARDS.

	Time.	Mean Velocity.		Muzzle Velocity.
35grs. Schultze	·0152 sec.	= 987 f.s.	+ 2%	= 1007 f.s.
42 „ „	·0135 „	= 1111 „	+ 2%	= 1133 „

OUR RECORDS FOR FIVE YARDS.

42grs. with 12-bore wads	·0153 sec.	= 982 f.s.	+ 2%	= 1002 f.s.
„ „ 10-bore „	·0134 „	= 1114 „	+ 2%	= 1136 „

As our charge from the paper case left the gun with about the same velocity as Mr. Griffith's, under similar conditions—and our charge from the "perfect" case was close to the velocity obtained by Mr. Griffith with 2½drs. Schultze and 1oz. shot—means of comparison exist for estimating the difference of speed with which the two charges would be likely to strike the target at 40 yards. The two records at that distance, however, were not made by the same means, as Mr. Griffith took chronographic velocities at 40 and 45 yards, whereas our records were taken by the force-gauge, of which the figures under the head of "Force per Pellet," when multiplied by 270 (the number of pellets per oz.), give an approximate representation of the striking velocity. On working out the results, we find that Mr. Griffith's figures indicate a difference of 38 f.s. between the striking velocity of the two charges at the target; whereas our force-gauge indicates a difference of 46 f.s. with black powder and 17 f.s. with Schultze.

The reason of the two charges striking the target with nearly the same amount of force, although the muzzle velocities were so wide apart, is thus accounted for. Previous records have shown that, in round numbers, a charge of No. 6 loses half its velocity in passing through the atmosphere for a distance of 40 yards; but with a very high muzzle velocity the loss may be more than one half, and with a very low muzzle velocity it may be less than one half. With shot leaving the gun at about 960 f.s. the loss of speed in 40 yards was about 420 f.s.; with that leaving the gun at 1000 f.s. the loss was about 450 f.s.; and with that leaving the gun at 1130 f.s. the loss was over 550 f.s. P.—T.

VELOCITY AND STRIKING FORCE OF SHOT PELLETS OF DIFFERENT SIZES.

(*Field*, Oct. 31, 1891; Vol. 78, p. 652.)

THE inquiries which are made by correspondents not unfrequently afford us an opportunity of imparting to others bits of information which we originally obtained for our own guidance. Such occurred when we gave particulars with respect to experiments carried out with paper (12-bore) and brass (10-bore) cartridge cases used in the same gun (see opposite page). The publication of our article on that subject has brought forth, from an old subscriber in Cheshire, a letter which also enables us to make some extracts from our notebook. Our correspondent, who has been pleased to write in very complimentary terms, says:

I am sure that the shooting men all over the country are very grateful to you for your very clear and exhaustive experiments on sporting gunnery which you so ably carry out from time to time. That of "Paper v. Brass Cases," in your issue of Oct. 17, is particularly interesting to me. I have hitherto refrained from using "perfects" in my heavy Greener 12-bore paper-case gun, thinking that the 10-bore wads would strain the gun and increase the recoil. I regret that you did not include a 60 yards test also, as it seems to me probable, as the "perfect" charge "pulled up" so much between 5 yards and 40 yards, that it would beat the paper case in velocity at 60 yards. If you cannot see your way to test this, I should feel greatly obliged if you will give me your opinion on this point. If this is so, I am sure the knowledge would be invaluable to wildfowlers who, like myself, use paper-case guns, with all the attendant inconvenience during wet weather. J. P. T.

In reply we may say that it is not at all probable—when charges of shot are of the same weight, and pellets of the same size—that one charge, which has lower velocity than another at 40 yards, would have the higher velocity of the two at 60 yards. As the distance increases, the difference between them goes on diminishing; and there is thus a general tendency for the two to approach equality; but if, by any "fluke," the slower charge could become the faster of the two, then its pellets would encounter more atmospheric resistance, and their speed, in like manner, would be brought down towards those which were slower.

It is hardly necessary for us to carry out experiments at 60 yards, as we can avail ourselves of information already in our possession. In the *Field* of Dec. 29, 1889, we published some records of chronographic experiments carried out by Mr. R. W. S. Griffith with different sizes of shot, in ranges varying from 5 yards up to 60 yards in length; and as J. P. T. asks for information that may be available in wildfowl shooting, it will probably be of more service to him if we give particulars respecting large sizes of shot, which do not lose speed so rapidly as the smaller pellets. Other of our readers, however, may perhaps like to see particulars about small shot; and so, having converted the previously-published records of time into the equivalent feet per second, we here give the velocities, by which means the variations can be more readily followed. These variations, however, should be considered as approximate rather than strictly exact; for, despite the utmost care, it is impossible, with the vagaries performed by several hundred pellets, to get the same amount of regularity as is obtainable with bullets.

The following table shows the mean velocities recorded for 5 yards, at different lengths of range, with 1oz. of shot, when propelled by 3drs. of powder on the one hand, and by 2½drs. on the other. These differing charges give near about the same muzzle velocities as the charge fired from paper (12-bore) and brass (10-bore) cases respectively, as stated in the previous article (p. 80). The first column of figures indicates the mean velocity for the first 5 yards from the muzzle of the gun; the next column gives the velocity in the 5 yards beginning at 40 and ending at 45 yards; and similar records follow, concluding with that for the space between 55 and 60 yards—the longest distance to which the trials were carried. It will be seen that, in all instances, the charge of shot propelled by 3drs. of powder starts with a speed exceeding that with the 2½drs. by about 150 feet per second with large shot, and more with small pellets. This advantage, however, is rapidly reduced by the resistance of the air; and how much of it remains, after the pellets have proceeded 40 yards or more, may be seen by reference to the "differences" set forth in the last lines of the following tables:

Mean Velocities for Five Yards, commencing at

No. 1 SHOT:	Muzzle. Ft.sec.	40 yards. Ft.sec.	45 yards. Ft.sec.	50 yards. Ft.sec.	55 yards. Ft.sec.
3 drs.	1154	777	701	636	577
2½ „	1007	697	649	598	526
Differences	147	80	52	38	51

Mean Velocities for Five Yards, commencing at

	Muzzle.	40 yards.	45 yards.	50 yards.	55 yards.
No. 2 Shot:	Ft.sec.	Ft.sec.	Ft.sec.	Ft.sec.	Ft.sec.
3drs.	1145	732	676	610	560
2½ ,,	993	673	625	568	497
Differences	152	59	51	42	63
No. 3 Shot:					
3 drs.	1128	701	641	577	538
2½ ,,	980	638	595	540	472
Differences	148	63	46	37	66
No. 4 Shot:					
3 drs.	1119	667	607	549	500
2½ ,,	968	610	566	512	444
Differences	151	57	41	37	56
No. 5 Shot:					
3 drs.	1111	636	581	505	461
2½ ,,	955	586	534	481	411
Differences	156	50	47	24	50
No. 6 Shot:					
3 drs.	1103	605	528	466	392
2½ ,,	943	556	495	441	378
Differences	160	49	33	25	14
No. 7 Shot:					
3 drs.	1095	577	497	405	324
2½ ,,	932	514	448	388	318
Differences	163	63	49	17	6
No. 8 Shot:					
3 drs.	1087	545	426	356	261
2½ ,,	920	476	394	319	228
Differences	167	69	32	37	33

On comparing these records, it may be observed that, with the large sizes of shot (from No. 5 upwards) the velocity of the pellets, when propelled by 3drs. of powder, is just about the same at 45 yards as with 2½drs. at 40 yards. This extra half-dram thus extends the killing power of the gun by about 5 yards; or, in other words, an addition of 20% to the powder lengthens the gun's range by a little more than 10%; and with small sizes of shot the increase is not so much. Hence, one cannot expect any great increase of killing power by adding to the powder a small fraction of a dram, such as ¼th. Moreover, it may be well for persons subject to "gun headache" to take note that recoil is increased in greater ratio than the killing power of the gun. In some recent experiments with No. 6 shot we found that, by increasing the powder from 3drs. to 3¼drs. (*i.e.*, an addition of about 8%), the velocity of the pellets at 40 yards was raised about 2%; the recoil, however, was increased by 11%.

Another circumstance may be noted, in connection with this table, viz., that a reduction of two sizes in the shot reduces the velocity to about the same extent as a difference of 5 yards in range. For example, on comparing these records, it may be seen that No. 1 shot at 45 yards has similar speed to No. 3 at 40 yards; and that at 55 yards No. 1 also accords with No. 3 at 50 yards. In like manner, No. 4 and No. 6 have nearly equal speed at 45 and 40 yards respectively; but at longer distances the small pellets do not keep in accord, as they so soon become exhausted, owing to their light weight.

While considering these variations in velocity, it will be well to bear in mind that the killing power of the shot does not vary in the same ratio as its speed. Take, for example, the records for No. 4 shot: the velocity with 3drs. at 45 yards is very similar to that for 40 yards with 2½drs., and, the velocity being nearly equal, the striking force would also be nearly alike at their respective distances. But at equal distances there is a marked difference. At 40 yards, for instance, the velocity with 3drs. is nearly 10% higher than with 2½drs.; but the advantage in killing power is not limited to 10%; as, on calculating out the "energy," or striking force of the shot, it is found that the advantage in this respect is about 21%. At 45 yards, the advantage in velocity is reduced to 7%; while in killing power it amounts to 14½%. And so it follows, as a general rule, that when the velocities of projectiles of equal weight are known, the superiority which one has over another, as regards velocity, may be taken as corresponding with rather more than double that amount of superiority in striking force.

With variations in weight of shot, however, it is rather troublesome to work out the differences; and we therefore give an extract from some tables we calculated for our own use. The figures between parentheses—as (270) after No. 6—show the number of pellets to an ounce of the respective sizes.

ENERGY OF SHOT PELLETS AT DIFFERENT RATES OF SPEED.

Velocity.	1oz. of shot.	No. 4 (174).	No. 5 (218).	No. 5½ (240).	No. 6 (270).	No. 6½ (300).
Ft.sec.	Ft.lb.	Ft.lb.	Ft.lb.	Ft.lb.	Ft.lb.	Ft.lb.
400	156	0·90	0·72	0·65	0·58	0·52
410	164	0·94	0·76	0·68	0·61	0·55
420	172	0·99	0·79	0·72	0·64	0·57
430	181	1·04	0·83	0·75	0·67	0·60
440	189	1·09	0·87	0·79	0·70	0·63
450	198	1·14	0·91	0·82	0·73	0·66
460	207	1·19	0·95	0·86	0·76	0·69
470	216	1·24	0·99	0·90	0·80	0·72
480	225	1·29	1·03	0·94	0·84	0·75
490	234	1·35	1·08	0·98	0·87	0·78
500	244	1·40	1·12	1·02	0·90	0·82
510	254	1·46	1·16	1·06	0·94	0·85
520	264	1·52	1·21	1·10	0·98	0·88
530	274	1·58	1·26	1·14	1·01	0·92
540	285	1·64	1·31	1·19	1·05	0·95
550	295	1·70	1·35	1·23	1·09	0·98
560	306	1·76	1·40	1·27	1·13	1·02
570	317	1·82	1·45	1·32	1·17	1·06
580	328	1·89	1·51	1·37	1·22	1·09
590	340	1·95	1·56	1·42	1·26	1·13
600	352	2·02	1·61	1·47	1·30	1·17
610	364	2·09	1·67	1·52	1·35	1·21
620	376	2·16	1·72	1·57	1·39	1·25
630	388	2·23	1·77	1·62	1·44	1·29
640	400	2·30	1·83	1·67	1·48	1·33
650	413	2·37	1·89	1·72	1·53	1·38
660	426	2·44	1·95	1·77	1·58	1·42
670	439	2·52	2·01	1·82	1·62	1·46
680	452	2·60	2·07	1·88	1·67	1·51
690	465	2·67	2·13	1·94	1·72	1·55
700	479	2·75	2·20	2·00	1·77	1·59
710	493	2·83	2·26	2·06	1·82	1·63
720	507	2·91	2·32	2·12	1·87	1·68
730	521	2·99	2·39	2·18	1·92	1·73
740	535	3·07	2·46	2·24	1·97	1·78
750	549	3·15	2·53	2·30	2·02	1·83
760	564	3·24	2·60	2·36	2·06	1·88
770	579	3·33	2·67	2·42	2·14	1·93
780	594	3·42	2·74	2·48	2·20	1·98
790	609	3·51	2·81	2·54	2·26	2·03
800	624	3·60	2·88	2·60	2·32	2·08

As the No. 5½ size (also called "medium game shot") and the No. 6½ (also known as "small No. 6," "No. 6* star," or "No. 6 Northern size") are a good deal used, we have thought it might be of interest to include them in the above table, although they were not used in the trial. For larger or smaller sizes, closely approximate estimates may be obtained by taking the records for three sizes smaller or larger, and halving or doubling them—thus:

No. 1 (94 pellets), double No. 4
No. 2 (116 ,,), double No. 5
No. 3 (139 ,,), double No. 6

No. 7 (340 pellets), halve No. 4
No. 8 (448 ,,), halve No. 5

There will, of course, be slight variations from strict accuracy in these estimates; but the differences are not nearly so great as occur between shot of the same nominal size issued by different makers.

The use of the Energy Table may be readily extended above or below the velocities there stated, by halving or doubling a given number, and multiplying or dividing by 4, as being the square of 2. Thus, if the energy of a pellet with 250 f.s. velocity be required, take that for 500, and divide by 4. Or if one for 1200 f.s. be sought, take that for 600, and multiply by 4. The effect will be similar to what is shown by 400 and 800 in the above table—the number of ft.lbs. in the bottom line being four times as great as those in the top line. If it should chance that a further extension were required, it may be met by substituting the numbers 3 and 9 for 2 and 4. The result is similar whether the quantities given in line 750 are divided by 9, or those in line 500 are divided by 4; they equally represent the energy for 250 f.s.

A combined use of these two tables may be made, and applied to ascertain the relative striking force of shot at different distances. Let us suppose that A. and B. are discussing the respective merits of

large and small shot—the former preferring No. 4 and the latter No. 7. It is claimed by B. that he has double the chance of hitting his game, because he has twice as many pellets; and A. retorts that he does not want to "stuff his birds with atoms of lead," but, when he does hit, he likes to kill. There is no doubt that B. has double the chance of hitting; and this chance he retains whether the distance is long or short. His pellets, too, may have ample force at short distances—though they never have half as much force as pellets of double their weight. They also lose their force more rapidly, as may be seen by the following comparison, in which are included some short distances not given in the first table.

Distance.	No. 4 Shot. Velocity.	Energy.	No. 7 Shot. Velocity.	Energy.	Proportion of Pellet Force.
20 yards	909 f.s.	= 4·64 ft.lb.	838 f.s.	= 1·97 ft.lb.	2¼ to 1
30 „	754 „	= 3·19 „	682 „	= 1·31 „	2½ to 1
40 „	667 „	= 2·58 „	577 „	= 0·94 „	2¾ to 1
45 „	607 „	= 2·07 „	497 „	= 0·69 „	3 to 1
50 „	549 „	= 1·70 „	405 „	= 0·46 „	3¾ to 1
55 „	500 „	= 1·40 „	324 „	= 0·29 „	5 to 1

Possibly, too, someone might like to know the total amount of energy in a charge of shot, when it leaves the muzzle of the gun, or when it has reached any given distance. Then the second column in the Energy Table will enable this to be ascertained for one ounce of shot (no matter what the size of the pellets may be, or whether in be a bullet); and if for a charge of other weight, the figures may be increased or diminished in proportion. Supposing, for instance, it is known that the muzzle velocity of a charge is 1200 f.s., and its remaining velocity at 40 yards is 600 f.s. The amount of energy in the former case is rather over 1400 ft.lb., and in the latter it is rather over 350 ft.lb. And it will be found that, whenever the velocity is reduced one-half between the muzzle of the gun and the target at 40 yards (and such is about the proportion with small shot), then no less than *three-fourths* of the energy originally contained in the charge has been expended in overcoming air-resistance for that short range. T.

LONG CARTRIDGES IN SHORT CHAMBERS.

(*Field*, Jan. 30, 1892; Vol. 79, p. 132.)

The probability of danger arising from the use of long cartridges in chambers of ordinary length—especially when the action of the gun is not a strong one—is a matter which is well worthy of consideration. In our impression of Jan. 16, 1892, under the heading of "Gun Barrels and Gun Actions," we published some very pertinent remarks by an old correspondent ("Beverley") with respect to the inadequate strength of many of the existing gun actions; and, since that letter was put into type he has sent us another, in which he says:

> The cry is "still they come." I enclose an empty 12-bore cartridge case, fired off yesterday; result, gun could not be opened for some time, and without some rough using. When it was opened, the cartridge was found to have split at the rim; and you will probably be able to guess what pressure there must have been to have caused such a strain on the gun; for, when closed again, there was a "gape" between the barrels and false breech to admit, say, a worn shilling. This gun was quite tight before the discharge. The charge used was 3¾drs. (by measure) of Schultze powder, with 1¼oz. of shot—a heavy charge, and far more than I durst have fired off, unless the gun was very substantially built (which I believe this gun was not). I did not see the gun, but a person who was present, and assisted in trying to open the gun after the shot, brought me the case to look at, and told me about the mishap.
>
> It is argued that Schultze does not put a greater strain on guns than black powder; but I am told this gun has usually been shot with 4drs. of black powder, and the same weight of shot, and never was strained.

Observing that the cartridge case received was of more than the ordinary length, we wrote to "Beverley," and requested him to ascertain the length of the chambers; for, if they were only bored for 2½in. cases, the overlapping paper of the cartridges would probably have something to do with the excessive strain.

The internal diameter of the 12-bore paper case is about ·730 inch, whereas the external diameter is about ·800 inch—the difference of about 70 thousandths of an inch being accounted for by the thickness of the paper. When a 2¾in. case is loaded, and the end turned in, it enters freely enough into the 2½in. chamber; but on the gun being fired, and the turnover of the cartridge unrolled to its full length, the paper overlaps the cone, and the space through which the shot and wads have to be driven is thus reduced to considerably less than that of the ordinary 12-bore dimensions. Accordingly, as the shot-charge is about to leave the case, it meets with an abnormal check; the pellets have to be jammed tightly together, in order to squeeze their way through the limited space; the powder, instead of burning at its ordinary rate of speed, has its combustion quickened, and the rapid evolution of gases in the confined space produces an intense strain in the chamber, until the shot, or the action, or both of them, give way under the enormous pressure.

"Beverley," having made inquiries about the gun, wrote as follows:

> Thanks for the insertion of my letter, which will, I hope, direct the attention of some gunmakers to the weakest part in our modern breech-loaders. As regards the cartridge I sent, I am told it was exactly as you surmised—the gun was chambered for short cases; consequently there would, as you state, be a greatly increased strain set up. I am much obliged to you for giving me particulars of your trials for pressure, when an ordinary case was used in an ordinary chambered gun, and when a long case was used. The results are most striking, and I think could not be too widely known. Perhaps you will let the sporting world see them in print.

About a twelvemonth previous a similar instance was brought under our notice, in which the owner of a gun, that had been regularly used for several years with 3drs. and 1⅛oz., increased his charge to 3½drs. and 1¼oz., and adopted longer cases to take the additional quantity of powder and shot. Much to his surprise, the action gave way. The maker of the gun could not satisfactorily account for it; he was of opinion that the damage might be due to excessive ramming of the nitro powder. But that supposition hardly seemed tenable; for if the cases were long, they would take the increased charge without any excessive ramming. However, we tested the matter, by using the same charge in long and short cases. In the ordinary case, the charge would have to be tightly rammed to get it into the cartridge; in the long case, the powder would not be tightly rammed, but the paper would overlap the cone.

The trial was carried out with several powders, besides the one which actually damaged the action, in order to ascertain whether there was any material difference in their behaviour under these circumstances; but the results showed that, in all instances, the overlapping paper produced greater strain than the same charge in shorter cases. We tabulate the records below.

The first column of figures gives the pressures in pounds per square inch with the ordinary charge of 3drs. and 1⅛oz., at three points, viz., first plug, 1 inch from the breech, and consequently at about the position of the powder wad; second plug, 2½in. from the breech, and therefore at the end of the chamber; and third plug, 6in. from the breech. The figures given are the averages of three rounds each. Where the letter X appears it indicates an "unknown quantity," as will be explained further on. Two kinds of black powder (C. & H. No. 2 and No. 4) were tested, and three nitro-compounds, as stated below. The words "small charge" indicate 3drs. and 1⅛oz., and "ordinary case" 2½in.; the "large charge" was 3½drs. and 1¼oz., and the "long case" 2¾in. All the cartridges were fired from a 2½in. chamber.

	Small charge in ordinary cases.	Large charge in ordinary cases.	Large charge in long cases.
No. 2 Black:			
First plug	6520	X	X
Second „	6169	6916	7059
Third „	3901	4270	4304
No. 4 Black:			
First plug	5603	6511	6752
Second „	5526	6004	6213
Third „	3694	3854	4012
Schultze:			
First plug	6406	7083	X
Second „	5369	5789	7010
Third „	3497	4240	4529
E.C.:			
First plug	5475	6194	6590
Second „	4695	5255	6357
Third „	3455	4019	3835
S.S.:			
First plug	5842	6992	X
Second „	4710	6135	7563
Third „	3578	4395	4410

For the records stated in the last two columns of the above table, the powder-charge used was 3½drs. In the gun alluded to by "Beverley," the charge was 4drs. with black powder, and 3¾drs. with the nitro-compound; consequently the strain in the chamber of that gun may be expected to have been somewhat more than that with the largest charge tried in the crusher-gauge. Whether the pressure from 4drs. of black powder was higher or lower than that from the 3¾drs. of nitro would doubtless depend on the size of grain, which is not mentioned. We should say that with No. 4 it would be rather less, and with No. 6 much less than with the nitros; but with No. 2 there would not be any great difference.

As to the probable amount of strain in those instances marked with

the letter X, we may say that it is not likely to have been under 8300lb. per square inch, but might be considerably over. The graduated table relating to the lead discs used in this crusher-gauge had not been framed for higher pressures than that above stated; but, from a rough estimate, based on the greater amount of flattening, we conclude that, with the large charge of No. 2 black, in the short cases, the pressure was somewhere about 8500lb.; but that with the long cases it was well over 9000lb. The highest pressures with Schultze and S.S. in the 2¾in. cases were just about the same as with No. 2 black. Schultze exhibited a further increase of strain when tried with 3in. cases, but we did not carry on the experiments in these cases with other powders. We have no doubt they would all increase more or less; but we are inclined to think that the nitros would increase more, and the black less. At all events, the greater the resistance is, the more uncertainty there appears to be in the behaviour of the nitro-compounds.

It will be observed, on referring to the foregoing table, that the pressures recorded by E.C. are much lower than those of the other two nitro-compounds. It would not be fair to our readers, however, to let them suppose that they can rely upon equally low pressures if they always make use of this explosive. We can only say that such were the records given by the sample of E.C. employed for these particular experiments. But, since those trials were carried out, we have had occasion to test other samples of the same powder, and have met with considerable variations in strength. Last month we received from correspondents several lots of E.C. cartridges, and two of the samples, which contained ordinary 3drs. charges, exhibited a much greater amount of strain than is recorded in either of the above records with a similar quantity of powder and shot. And it may be inferred that, as increased strain was shown with the small charge, there would in all probability be a corresponding increase with larger charges likewise.

With respect to the black powder records given above, it may perhaps be said that No. 4 grain is far more generally used than No. 2, and that it is needless to attach much importance to the high pressures recorded by the latter. Such is doubtless correct so far as regards the majority of people who still use black powder alone. But the fact should not be lost sight of that many sportsmen use a nitro-compound in the first barrel, in order to obtain the advantage of its smokelessness, but have recourse to black powder in the second barrel, because they believe it will kill farther. When such is the case, it frequently happens that the powder used is either No. 2 or fine-grain "basket" powder, both of which have greater propelling force than the nitro-compounds or than the coarser-grain black powders; and with this greater propelling force, increased strain in the barrel is a necessary accompaniment.

Balled Shot.

Hitherto we have only alluded to the danger that probably may be encountered by those who use long cartridges in short chambers; but there is also to be considered the amount of risk which they may inflict upon other people. The crushing together of the pellets in the cone is very likely to cause the shot to "ball;" and the distance at which balled shot may do serious injury, or even produce fatal effects, may be seen by the following extract from the *British Medical Journal* of June 23, 1888. The particulars are condensed from a report given by the surgeon who attended to the injuries of the wounded man:

> W. L., when leading a horse and cart along the road, heard two shots in quick succession; the second struck him in the face, and caused a roundish wound, large enough to admit a finger. The jaw was broken, and some teeth were carried away, and there was also a small wound on the cheek, which might have been made by a single pellet of shot. . . . The probe detected some hard substance, which was grasped by forceps, but crumbled under its grip. Withdrawal of the forceps was accompanied by a shower of shot falling to the floor. The blades held a lump of four pellets firmly stuck together, and much of what was then and subsequently removed consisted of pellets in twos and threes. The amount recovered was one-third of an ounce. The shot was fired from the raised bank of the Trent across a field, the distance to the road being 133 yards. It was fired at and killed a pheasant. The shooter saw the cart, but said it was out of the line of fire.
>
> The points worthy of notice are: 1, the distance—133 yards; 2, the amount of shot recovered—one-third of an ounce; 3, the statement that the man was out of the line of fire. In regard to point 3, I have been told of two other cases of *stray* pellets hitting persons quite out of the line of fire. As to point 2, the shot was carried in a lump; and this perhaps explains point 1. M. R. J. Behrendt, L.R.C.S. and P., Ed.
>
> Burringham, Doncaster.

In this paragraph there is nothing to show what was the length of chamber or cartridge; but in other instances where shot has "balled," evidence has been forthcoming to demonstrate the cause. From some experiments which we previously carried out (see p. 100), it appears that it is most likely to occur when there is a constriction in the barrel at a short distance from the breech, in front of the shot, especially if it is a quick-burning powder; and an ancient flint gun, which had such a constriction, and was shot with powder of very fine grain, was marvellous for the frequency with which it caused the shot to ball.

A similar effect is produced in modern guns when the space in front of the chamber is constricted by the overlapping of the paper case. Some years ago the use of Schultze powder was prohibited at the Gun Club, owing to the frequent balling of shot, which was supposed to result from the introduction of this nitro-compound. But balling still went on when only black powders were allowed; and eventually it was traced to particular guns, from which larger charges were fired than those for which the barrels had been chambered, and in which, consequently, long cartridges were adopted. The use of such guns having been stopped, the balling ceased, and the prohibition against the nitro powder was withdrawn.

It would be well if those people who wish to use larger charges in their guns would have the chambers altered to take the required cartridges. They would thus reduce the strain upon the action, and consequently run less risk themselves, and would also have the satisfaction of knowing that their guns will be less dangerous to other people. P.—T.

TESTS OF STRAIN ON BREECH ACTIONS.

(*Field*, May 21, 1892; Vol. 79, p. 772.)

Owing to complaints that have been made in our columns with respect to the straining and breaking of gun actions, it has recently been suggested that we should carry out a trial for the purpose of determining which is the strongest of the various breech-loading actions now made for sporting guns. We have hesitated, however, to undertake this task—not because we wished to avoid the trouble of carrying out the trial, but because we could not see that, when carried out, it would be likely to attain the end for which it was proposed.

The information that is wanted, as it seems to us, is not such as would show the greatest degree of strength discoverable among a number of good sound actions about which no complaint has been made; it should rather, we think, be such as would indicate the weakness of those actions which are a frequent source of compiaint, and which would not be brought forward in any competition. In other words, the question at issue is the detection and rejection of such actions as may probably fail with a charge of 3¼drs. or less, and not the ascertainment of which particular action will stand 6drs., and which 7drs., or even more. Few persons, we imagine, would ever want to increase their charges to such an extent as would necessitate the turning of their breechloaders into muzzle-loaders for the time being; but everyone, we think, would wish his gun to be strong enough to withstand the strain produced by any cartridge which might, either intentionally or through inadvertence, be inserted in its chamber.

Taking these circumstances into consideration, we thought we might perhaps render greater service to our readers if, instead of attempting to carry out the proposed trial, we endeavoured to ascertain how far the strain upon gun actions is likely to extend when large but not impossible charges are used. It not unfrequently happens that one member of a shooting party may run short of cartridges, and borrow a few from a friend without inquiry as to what they contain; or a man may increase his charge for wildfowl, or pigeons, or some other special purpose, without considering whether his gun is strong enough to bear the alteration. If, however, the probable extent of the strain were ascertained, it might not be difficult to find a test which would enable the owner of a gun to determine for himself whether its strength could be relied on.

In a previous article (page 83) we published particulars showing that there is a considerable increase in the strain on a gun action when a long cartridge is used in a short chamber. On the gun being fired, the strain is augmented, not merely by the larger charge contained in the cartridge, but also by the resistance arising from the paper, when unrolled, overlapping the cone, and thereby restricting the space through which the shot has to be driven. Hence the pressure exerted in an ordinary gun is greater than would result from firing the same cartridge in a 3in. chamber, although the latter would (under the Rules of Proof) have to undergo the test of a larger proof-charge. When we published the above-mentioned article, we were unable to state the full extent of strain developed, as the crusher-gauge apparatus then used had not been constructed to register such unusual pressures. But the apparatus has since been altered, and we are now able to give much higher records.

We need hardly say that there is a considerable difference in the amount of strain exhibited by different powders when fired under

similar conditions. With black powders, equal in quality, the largest grain gives the lowest pressure; and with nitro-compounds, there are some differences which arise from variations in the chemical constituents and details of manufacture, and others that are due to the amount of resistance encountered. Evidence of this will be found in the following table, in which are stated the pressures recorded by three rounds fired with each charge. We give records of the individual rounds, as well as the average in each instance. The pressures are stated in tons per square inch, and decimals of a ton. We may add that the cone of the gun in which these pressures were taken was very long and gradual. If the cone had been more abrupt, the strain with the long cases would doubtless have been more severe.

Charges of Powder and Shot fired in gun with 2½in. chamber.	Black Powders.			Nitro-compounds.		
	No. 6.	No. 4.	No. 2.	Schultze.	E.C.	S.S.
3drs. and 1⅛oz., in 2½in. case ...	1·58	2·50	2·55	2·50	2·34	2·40
" " " " " ...	1·58	2·74	2·92	2·74	2·34	2·55
" " " " " ...	1·32	2·55	2·60	2·96	2·45	2·45
Averages...	1·49	2·66	2·69	2·73	3·38	2·47
3½drs. and 1¼oz., in 2½in. case ...	2·29	3·74	4·09	3·71	4·33	5·05
" " " " " ...	2·29	3·71	4·12	3·87	4·24	5·07
" " " " " ...	2·24	3·54	4·24	3·87	4·18	4·77
Averages...	2·27	3·66	4·15	3·82	4·25	4·96
Same charge in 2¾in. case ...	2·50	3·87	4·36	4·27	4·85	5·36
" " " " " ...	2·60	3·90	4·33	4·27	5·07	5·44
" " " " " ...	2·50	3·81	4·44	4·30	4·85	5·50
Averages...	2·53	3·86	4.38	4·28	4·92	5·43
4drs. and 1⅛oz., in 3in. case ...	4·39	5·72	6·08	5·74	5·57	6·18
" " " " " ...	4·33	5.52	5·92	5·48	5·15	6·52
" " " " " ...	4·36	5·61	5·90	5·50	5·52	6·40
Averages...	4·36	5·62	5·97	5·57	5·41	6·37

The mode of loading was the same for all powders in the same series, and Eley's 12-bore green cases were used throughout; their length varied as stated in the table. For the charge of 3drs. and 1⅛oz., the ordinary "Field" loading was adopted, viz., a 11¾ black-and-pink wad on powder, then ⅜in. felt, with thin card between felt and shot, and another card over the shot. With 3½drs. and 1¼oz., in the 2½in. case, the felt had to be omitted, through want of room, and a second black-and-pink wad was substituted; but with the same charge in the 2¾in. case, the complete "Field" loading was resumed, and also with the 4drs. charge in the 3in. case. The black powders here used were Curtis and Harvey's T.S.; later on some of their Diamond Grain was also used.

We likewise tried a number of experiments with larger charges than are stated above; but the mode of loading had to be altered, as the cartridge cases would not hold the entire charge. Accordingly, powder and wads were put in 2½in. cases, with extra felt where required to fill up the case, and the paper turned over to the usual extent; the shot was loaded from the muzzle, and a thick cloth wad rammed on the top to keep the shot in its place. In consequence of this alteration, the resistance which had arisen in the cone from the overlapping paper did not occur, and the strain was reduced. For instance, when 4½drs. of powder, and 1¼oz. shot were loaded in this manner, the pressures per square inch averaged about a ton less than those shown with the 4drs. charge in the above table. And with 5drs. likewise the records were also below those stated above. With 6drs. and 1¼oz., however, there was generally, but not invariably, an increase on the record made by the 4drs. charge in the 2½in. chamber.

Some time ago we expressed our willingness to test certain guns which were offered to us for trial with large charges. We now give particulars of the guns which have been tried, and the tests to which they have been submitted in accordance with the instructions given by the owners of the guns:

Gun Lent by the Schultze Gunpowder Company.

An old 12-bore gun, made in 1878, and used for experimental purposes in the Schultze Gunpowder Works for nearly fourteen years, during which time more than 100,000 rounds had been fired with charges varying considerably in amount of powder and shot. Weight of gun, 7lb. 9oz.; length of barrels, 30in. Bar action, with Purdey under-bolt and Greener top cross-bolt. Maker, W. W. Greener. Charge used for this trial, 84grs. of Schultze (equivalent to 6drs.), and 1⅛oz. of No. 6 shot. The powder, and the 11¾ gauge "Field" wad, ⅜in. felt, and card, were loaded in a 2½in. cartridge case, which was then turned over, and the shot and shot-wad were added from the muzzle. Five rounds were fired from each barrel, and the gun stood the test perfectly. The strain which was produced by this test charge averaged 4·74 tons per square inch, or about a quarter of a ton more than the ordinary proof-charge, of which particulars are given at the end of this article.

Gun Lent by Mr. F. G. Heygate.

New 12-bore gun; weight 6½lb.; length of barrels, 30in. Action, Anson and Deeley type; no doll's-head or other top extension; barrels gripped by Purdey bolt only. Makers, Cogswell and Harrison. Ordinary charge 3drs. of powder and 1⅛oz. of shot. Charge used for this trial, 63grs. of Schultze (equivalent to 4½drs.) and 1¼oz. of No. 6 shot. As the cartridge cases would not contain this test charge, the charge of powder, with 11¾ guage *Field* wad, thick felt, and card, were put in the 2½in. case, and turned over; the shot charge and wad over the shot were inserted at the muzzle. Five rounds were fired from each barrel, and the gun stood the test perfectly. The strain produced by this test charge averaged 4·58 tons per square inch, or rather more than that of the ordinary proof charge, of which only one round is fired from each barrel.

Guns sent by Messrs. Trulock and Harriss.

The following letter from Messrs. Trulock and Harriss will describe the conditions under which their guns were sent for trial:

Sir,—We are anxious to have three of our guns tested in the way you suggest—viz., with a charge that will give 50 per cent. greater pressure than a charge of 3drs. powder and 1⅛oz. shot, for which the guns were originally built. For this purpose we have asked two of our customers, who for the last two seasons have shot with ejector guns of our make, to allow us to send them on to you, and they have kindly consented. All three guns are fitted with Webley's screw grip, which we have used for years. So strong is our belief in this screw grip, that we will ask you, after you have tested them as they are now, with the double bolt and screw grip, to remove the double bolt, and then test them again with the same charge. When the double bolt is removed, the lever will have to be kept back with the thumb, so as to let the barrels close, as it is the bearing of the front lump on the under bolt that holds the lever open.

The pair of sidelock guns are the property of C. Beresford Whyte, Esq., D.L., Hatley Manor, Carrick-on-Shannon. The Anson and Deeley is the property of H. Vincent Jackson, Esq., J.P., Galtrim House, co. Wicklow. We wish to point out to you that, although this latter gun is only 6lb. weight, we are sure it will stand the test.

We might also explain why all three guns have such an apparent excess of cast-off. It is the result of very careful trials of Jones's try-gun at our range; and both Mr. Whyte and Mr. Jackson have authorised us to state, for the benefit of your readers, that this try-gun has much improved their shooting, and that they are firm believers in its efficiency.

9, Dawson street, Dublin. Trulock and Harriss.

Mr. Beresford Whyte's pair of 12-bore guns weigh 6lb. 13oz. each; they have 30in. barrels, with Purdey under-bolt, and Webley's screw grip on extended rib. Makers, Trulock and Harriss. These guns were fired with 3½drs. C. & H. No. 4 Diamond grain powder, and 1¼oz. shot; wads, a thin card on powder, ⅜in. felt next, and a card over shot; the *Field* wad was omitted, in order to get the charge into the 2½in. case. Five rounds were fired from each barrel (with a strain averaging 4·20 tons per square inch), and both guns stood the test thoroughly.

Mr. Vincent Jackson's gun, a 12-bore with 30in. barrels, Anson and Deeley action, and Webley's screw grip, weighs only 6lb. Makers, Trulock and Harriss. It was tried with exactly the same charge as Mr. Beresford Whyte's guns, and withstood thoroughly five rounds from each barrel. Average strain as before stated.

These three guns were, in accordance with the suggestion of Messrs. Trulock and Harriss, afterwards tried again with the screw grip as the only fastening, and they still stood the test perfectly.

An Old Pin-fire Gun.

We had in our possession an old pin-fire gun, which was made by Mr. W. W. Greener a quarter of a century or more ago for the late Mr. Serjeant Cox, and had been used by him and a member of his family, to whom he gave it, for many years, until it became loose in the joint, when it was discarded in favour of a more modern weapon. It has since been lying about for years, and got somewhat the worse for rust; but, as we were trying the stability of other guns, we thought we would ascertain what this "old crock," which had been a good gun in its time, would stand now. The gun weighs 6lb. 14oz., has 30in. barrels, and a single snap grip without any top extension. It was tried with 3½drs. of No. 4 Diamond grain powder and 1¼oz. shot, loaded as described in previous paragraph; five rounds were fired from each barrel (average strain 4·20 tons per square inch), and it came out of the trial perfectly unharmed.

In connection with this subject of the strain upon gun actions, we recently received the following letter from Mr W. Ford, of Birmingham:

SIR,—I should be glad to hear your opinion as to whether you consider or not that there is a greater strain on the breech action of a gun in testing it with, say, 48grs. of nitro powder and 1¼oz. of shot in a 3in. case, and giving it a big turnover, than when tried with the usual final proof-charge; and it would be valuable information if you could state the difference between these two charges by testing them with the crusher gauge.

I beg to mention the following experiment that I have made, and find that, to remove a plug from a case turned over ⅛in. (the plug turned to fit the case, with a rod screwed into the plug after being turned over, and then suspended by the head), that it takes 32lb. dead weight to draw the plug out; and when using cloth wads instead of the plug, and the same turnover, and a screw put into the wads, it takes more than double the above weight to draw the wads. Now, I think you will find that a much greater strain is thrown upon the breech action with 48grs. of powder and 1¼oz. shot in a 3in. case well turned over, than double that charge of powder and 1⅝oz. of shot and not turned down.

I had an instance of a test in a breech action only a few days since, a gentleman using 2½in. cases in a gun of mine chambered only for 2½in. cases, and, had the chambers not been coned, it would undoubtedly have strained, if not broken, the action; whereas, being coned, it was all right.

WM. FORD.

We have tried a few experiments with several powders, in order to ascertain the amount of strain produced by 3¼drs. and 1⅛oz. shot, loaded under the conditions stated by Mr Ford. We have also tried the definitive proof-charge of 1⅜oz. No. 6 shot with 6½drs. of London proof-powder (which we conclude is similar in strength to that employed in the Birmingham Proof House), and we must confess that we found it gave much less strain than we imagined it would do. As the Rules of Proof state that the gunpowder to be used for proof purposes "shall be of strength equal to Waltham Abbey R.F.G.^{2}" (*i.e.*, the Government powder made for use in the Martini-Henry rifle), we likewise tried some powder taken out of Martini-Henry cartridges; and there certainly was not much difference in the records of pressure made by these two kinds of powder; nevertheless, the strain in each case was considerably below the pressure exhibited by black sporting powders, when tried with similar charges, and likewise lower than some ordinary service charges, as will be seen by the following summary of results:

PROOF CHARGES.	Average pressures per square inch.
6½drs. of Proof powder and 1⅜oz. of No. 6 shot	4·51 tons
,, Martini-Henry powder ,, ,, ...	4·67 ,,
,, C. & H. No. 6 T.S. ,, ,, ...	5·74 ,,
,, ,, No. 4 T.S. ,, ,, ...	7·10 ,,
,, ,, No. 2 T.S. ,, ,, ...	7·23 ,,
SERVICE CHARGES.	
3½drs. C. & H. No. 4 T.S. and 1⅛oz. shot, in 3in. cases	4·29 tons
,, Schultze powder ,, ,, ...	4·33 ,,
,, Schultze ,, ,, in 2½in. cases	4·28 ,,
,, E.C. ,, ,, ,, ...	4·92 ,,
,, S.S. ,, ,, ,, ...	5·43 ,,
,, C. & H. No. 2 T.S. ,, ,, ...	4·38 ,,
,, ,, No. 2 Diamond grain, in 2½in. cases	4·88 ,,
,, ,, No. 3 ,, ,, ,, ...	4·87 ,,
,, ,, No. 4 ,, ,, ,, ...	4·20 ,,

On comparing the records of Service Charges with the first line under the head of Proof Charges, it will be seen that Mr. Ford's prognostication is quite fulfilled. Not only did a nitro charge, under the conditions he stated, exceed the pressure of the definitive proof-charge, but similar charges of both nitro and black powders did the same with shorter cartridges and less turnover. These results tend to confirm the opinions urged by Mr. Greener and others, about five years ago—when the revision of the Rules of Proof was under discussion—viz., that the powder employed for the proof of sporting guns ought not to be weaker than the No. 4 grain ordinarily used in such guns. This proposed alteration was rejected as a general rule, but a supplementary arrangement was made, which is stated in the Rules of Proof (1887) in the following words:

Barrels for arms of any class shall, at the request in writing of any person or persons sending the same for definitive proof, be proved with Schultze's or E.C. powder, *or any particular description of gunpowder which may be specified by the sender*, after and in addition to the ordinary proof.

Looking at the results demonstrated by the above-mentioned experiments, we should advise those who are ordering new guns, upon the soundness of which they desire to place full reliance, to give instructions that they shall be proved with No. 4 black sporting powder (either Curtis and Harvey's, or Pigou and Wilks's, or any other firm they may prefer), in addition to the ordinary test with the common proof powder; and we are of opinion that the extra fee of 1s 6d. per barrel will be well expended. We do not recommend that the guns should be proved with nitro-compounds, as we believe that these explosives are not so reliable for proof purposes as really good black powders.

As to guns that are already in existence—the reliability of many of which is doubtful—we have no wish to dictate what the owners should do; we will merely state the courses that are open to them. There are, we believe, now in use an abundance of guns which would pass unscathed through any test to which they could reasonably be submitted. Besides these, however, there are many, made before the new Rules of Proof came into force, that are a constant source of danger to the people who use them. All the broken actions that have come within our notice belonged to this category; they were in guns made under the former Rules of Proof. Should any of our readers own such a gun, about the safety of which he is in doubt, he can have it proved anew at one of the official proof-houses, if he is so disposed; or, on the other hand, he can go on as hitherto, and "take all risks." There is a third method, however, which is open to him, and that is, to do intentionally what many people often do inadvertently—make use of a few cartridges containing heavier charges than they are accustomed to shoot with.

For such a purpose, the information as to pressures given in this article may perhaps prove of service. Thus, supposing that a man has a 12-bore gun, ordinarily used with 3drs. of powder and 1⅛oz. of shot, and he feels doubtful as to what might happen if he accidentally thrusts into the chamber a cartridge containing 3¼drs. and 1¼oz., the above tables may give him an idea of the extra strain which may result from the inadvertence, according to the kind of powder used; and, should he feel inclined so to do, he may ascertain for himself whether his gun would withstand such a strain.

With C. & H. No. 4 T.S. powder, the larger charge, in 2½in. cases, would increase the strain about 40 per cent.; with the same charge in 2¾in. cases, the increase would be about 50 per cent. With Diamond No. 4, or finer-grained black powder, or some of the nitros, the strain would be greater; and so on. If he wishes to give a still more severe test, he can increase the charge and lengthen the cases. Of course, it is to be expected that actions, if not barrels, will occasionally give way under these tests; but, should such be the case, it is much better for the breakage to happen when precautions can be taken to avoid danger, instead of occurring while the gun is in ordinary use, when serious injuries might possibly result to the person who fires it.

It is not necessary, in carrying out these tests, that the experimenter should run any risk by firing the gun from his shoulder. It could easily be arranged for the barrels to rest on a bag stuffed with hay or chaff, and the stock be backed up by a similar bag, while the operator, standing behind a door, could pull the trigger in safety by means of a piece of twine.

P.—T.

THE BURSTING OF SMALL-BORE GUNS.

(*Field*, March 21, 1885; Vol. 65, p. 365.)

THE correspondence recently published in the *Field*, with respect to the many guns which have burst of late, has raised various questions of considerable interest and importance. Probably most of the causes suggested may, in a greater or less degree, have something to do with the origin of such disasters; but it seemed to me that inefficiency of "proof" was the chief offender; and having, after reading the leading article in the *Field* of Feb. 28, examined the Proof Acts somewhat more carefully than I had hitherto done, I observed therein various rather noteworthy facts, which will probably be little known to most people, and may therefore be deserving of comment.

It is generally acknowledged that the great amount of mischief which has been done has been with guns of small bore. Occasional instances have occurred, no doubt, where 12-bores have been crippled or severely shaken; but in some of these it has been conclusively proved that the results have been due to the use of excessive charges of the nitro-compounds, and in others to the undue rapidity of combustion produced by "baking" the powder or cartridges. It is to be hoped that the danger arising from the latter cause is now at an end, and that Schultze and E.C. may be found, on more extended trial, to retain their former good qualities without the risk that has hitherto been shown to result from injudicious treatment. It seems pretty clear, however, that the powders are not the sole cause of the damage that has occurred; for the percentage of burst guns has been vastly greater in 16 and 20 bores than in the more common 12-bore. Small-bore guns have come much into vogue in the last few years; yet they still form but a limited portion of the guns in use, whereas they have nearly a monopoly of the mischief.

The great rage for light guns has doubtless very much to do with this. People are so chary of carrying a gun of the weight which their forefathers would have thought light and handy, and are so anxious to get rid of a few ounces, that it is not surprising there are plenty of gunmakers ready to meet their requirements, and to outbid one another in the extent of reductions. It is not uncommon for small barrels to be made thinner than large-bores because the charge of powder is less; but the strain does not depend alone upon the quantity of powder—it increases with the amount of resistance which the gas meets with when the powder is fired; and in small-bores the obstruction from the turn-over of the cartridge and other causes is often greater than in large-bores—that is to say, in guns as used by sportsmen. Unfortunately, however, such resistances are not developed in the proving of ordinary shot guns, and the smaller the bore the less effective does the proof become as a test of the strength of the barrels; for there are no turned-over cartridges, and the other means of resistance gradually dwindle away with decrease of gauge, as will be explained further on. But meanwhile it may perhaps be of service to those who have not inquired into this part of the subject, if a few words are said as to the effect of such obstructions in influencing the amount of strain put upon the barrel.

Many sportsmen are apt to look upon gunpowder as though it developed a specific amount of force in proportion to the quantity employed, and thus conclude that a small-bore gun for use with 2drs. or 2½drs. of powder may be reduced in strength as compared with a larger gun that is used with 3drs. or 3½drs. It is not an unreasonable supposition, as it seems natural enough to suppose that, by doubling the charge of powder, the force produced would also be doubled. In fact, however, such is by no means the case—*i.e.*, under the ordinary conditions of use by sportsmen. Indeed, in one sense, it may be said that the potential force of every charge of powder they fire is practically unlimited; as, when the powder is ignited, the pressure increases, and continues to increase, until something or other gives way. Ordinarily the shot gives way, being set in motion before the combustion of the powder is completed; but, if anything retards such movement, the gas grows in strength until it overpowers the resistance, either by expelling the shot or bursting the barrel; for no ordinary fowling-piece would be likely to withstand the utmost development of force of which gunpowder is capable.

When a chamber, strong enough to resist such tension, is filled with black gunpowder, the strain put upon its unyielding walls by the firing of the charge has been found to reach about 42 or 43 tons per square inch. The details of the experiments, as carried out by Sir F. Abel and Capt. Noble, have been described at great length in the Philosophical Transactions of the Royal Society. This pressure per square inch is producible by small charges as well as by large; but, of course, in the latter it extends over a larger amount of space. It has been estimated by other experimenters that in the chamber of a 12-bore shot gun, with ordinary conditions of loading, the pressure is somewhere about one ton per square inch, or less than a fortieth part of the fully-developed force of the powder. But the strain of the ordinary charge of powder will be quickly increased by augmenting the charge of shot, or otherwise obstructing the expansion of the gas. Thus, the resistance in a rifle is greater than in a smooth-bore, and the force of the powder is developed accordingly. The charge of powder used in the Snider rifle is rather less than in the 12-bore shot-gun, and yet the pressure in the former barrel is twice as great as it is in the latter. In the Martini-Henry the charge is but a fraction over 3drs., and its bullet is the same in weight as the Snider; but, owing to the smaller bore and sharper twist, the strain is more than doubled, the pressure in the Martini being estimated at between four and five tons per square inch, as against two tons in the Snider. Again, in the Gatling machine-gun the powder and bullet are exactly the same as in the Martini, but there is a thicker brass cartridge-case, in which the bullet is more rigidly fixed. Here once more there is greater resistance, and the strain rises to about seven tons per square inch.

Taking such matters into consideration, we might infer that, within certain limits, small-bores should be made stronger than large-bores, instead of the reverse, seeing that they are more likely to produce obstruction, and thus give rise to a greater strain. Many persons nowadays are using in 20-bores as heavy charges of shot as others have been accustomed to employ for 12-bores. Supposing that an ounce of shot were used in each, there would necessarily be more resistance in the smaller bore, owing to the greater length of the charge. In the scale of proof for rifles introduced into the Proof Act of 1868, due attention was evidently paid to the effect of such increased resistances, and we accordingly find that the amount of lead required for proving rifles became relatively larger and larger as the bore decreased in diameter. With shot guns the very opposite of this is the case. The practice of olden times, of using a spherical bullet, is continued, and consequently, if the diameter of the bore is reduced one-half, the bullet is only one-eighth of the former weight. The charge of powder prescribed is no doubt immense in many cases, and people are consequently led to suppose that their guns have been tested far beyond all ordinary requirements; but the other conditions are such as to render the test almost nugatory with small bores. One does not find rifle barrels burst with the frequency of those of shot-guns; and yet the quantity of powder used in proving smooth-bores is often higher than that required for rifles, as will be seen by the following comparative table:

Bore of Gun Proved.	Proof of Smooth-bores.		Proof of Rifles.	
	Charge of Powder Used.		Charge of Powder Used.	
	First Proof.	Second Proof.	First Proof.	Second Proof.
12-bore	12¾drs.	8 drs.	10½drs.	6¾drs.
14-bore	11½drs.	7 drs.	9 drs.	6 drs.
16-bore	10¾drs.	6¾drs.	8½drs.	5½drs.
18-bore	10 drs.	6½drs.	8 drs.	5½drs.
20-bore	8 drs.	5 drs.	7¾drs.	5½drs.
22-bore	7½drs.	4½drs.	7¾drs.	5 drs.
24-bore	6¾drs.	4½drs.	7½drs.	5 drs.
28-bore	6¾drs.	4½drs.	7½drs.	5 drs.

In rifles, the quantity of powder used by sportsmen often exceeds that of the second-proof charge, and occasionally goes up nearly to that of first-proof. In express rifles of ·577 bore (which is just about equal to the 24-bore of shot guns), 6drs. and even 7drs. of powder are used by sportsmen, whereas the charge employed for second proof is only 5drs.; yet the rifles withstand such charges, owing, no doubt, to the fact that the bullets used for proof are much heavier than the bullets used by the sportsman. On the other hand, the ordinary sporting charge of powder in shot-guns is only about one-third or one-fourth of the quantity required for first proof, or one-half to one-third of that required for second proof; and yet the barrels of smooth-bores so frequently fail with the small charges of ordinary use, that many people suppose the tubes must have been injured by an excess of strain produced by the immense charge of powder employed in proof. The fact of the matter, however, would seem to be, that this excessive strain really does not exist; for the quantity of lead is so small that it does not sufficiently develope the force of the powder, and the narrower the gauge the more fallacious becomes the test; whereas, in small-bore rifles the proportion of lead for proof increases as the bore diminishes.

The relative quantity of lead used in proof of smooth-bores and rifles will be seen by the following figures, which are given to the nearest approximate weights in ounces:

Bore of Gun Proved.	Proof of Smooth-bores.		Proof of Rifles.	
	Spherical Bullets used.		Flat-ended Cylinders used.	
	Gauge.	Weight.	Length.	Weight.
12-bore	13-bore	1¼oz.	1·5 diameters	2¾oz.
16-bore	18-bore	¾oz.	1·5 diameters	2¼oz.
20-bore	22-bore	⅝oz.	1·6 diameters	1⅞oz.
24-bore	27-bore	½oz.	1·8 diameters	1⅝oz.
28-bore	31-bore	⅜oz.	2·1 diameters	1⅜oz.

The spherical balls (for which, however, cylindrical or conical bullets of equal weight may be substituted) are used for smooth-bore guns that are not choked; for those that are choked, an equal weight of No. 6 soft shot is substituted in the second proof. For proving rifles the bullets must be flat-ended cylinders of lead.

This alteration with respect to the use of loose shot is a decided improvement; but it should not be limited to choke-bores. A solid ball is not an efficient mode of proof for any gun to be used with small shot; and, if of its full nominal size, it might not pass through some portion of the bore even in what is called a "cylinder" gun, although there might be plenty of room for it in other parts. In the loose charge there is some degree of compressibility as well as some risk of compaction; and the risks that are likely to occur in the ordinary use of the gun ought not to be avoided in proof. When a

cartridge is fired, the pellets are liable to be compacted and wedged in upon one another by a pressure vastly greater than that of any steam roller. As the mass is driven together in length it would be squeezed out in breadth; and, the smaller the bore, the greater the probability of a "jam." The turn-over of the case increases this liability, as the roll of paper covers a larger proportion of the outside wad, and the shorter radius affords less leverage for prising it open; consequently more force must be developed before the shot can be driven out. Under any circumstances the pellets must be pressed against the walls of the barrel by enormous force, as is evidenced by the grooves cut in the lead cylinders (see pages 24 and 25); and in the more restricted space of narrower bores the percentage of pellets impinging on the walls would necessarily be increased.

It seems not improbable that such influences may have had something to do with the number of small-bore guns that have been damaged of late. In a burst 20-bore, which I recently saw, extra long cartridges had been used with a full ounce of shot; and there must necessarily be great resistance with such a charge in so narrow a bore.

The above-mentioned proof regulations are of comparatively recent date. Under the Act of 1813 (which continued in force up to 1855), guns were only required to withstand a single proof; and the test was alike for all fire-arms of the same bore, whether single or double, smooth-bores or rifles. They were proved with somewhat heavier charges of powder than are now used for first proof, and with spherical bullets of lead corresponding to the size of the bore. Thus, the 4-bore took a ball of ¼lb. weight, the 8-bore took one of ½lb. or 2oz., the 12-bore took one of 12 to the pound, and so on.

From the time the Act of 1813 was repealed, and the Act of 1855 came into operation, the quantity of powder for proving single smooth-bores has been reduced, and the manner of proving rifles and double-barrelled guns has been made optional, as they could undergo either a single or a double proof. The latter has been generally adopted by the trade, from the manifest advantage it affords of testing the strength of the barrel before much money has been expended in the construction of the gun; for the tubes are proved separately, in a rather crude condition, with a large charge of powder, and, when they are put together and virtually completed, they are tested again with a smaller charge. On the other hand, if they were only submitted to one proof, the barrels would have to be put together, and rifled if necessary, and completed as for second proof, but would be submitted to the full charge of powder used with first proof; consequently, if a barrel were then to burst, the expense of the additional labour would have been thrown away.

The following figures will show the charges of powder used in the proof of a few of the various bores under the Act of 1813, and also under the Act of 1855, when there was a reduction of 20 per cent. on the charge for first proof (whether definitive or otherwise), while the second proof was 50 per cent. below the 1813 scale:

	Act of 1813.	Act of 1855.	
	Single Proof.	First Proof.	Second Proof.
12-bore	16 drs.	12¾drs.	8 drs.
16-bore	13½drs.	10¾drs.	6¾drs.
20-bore	10 drs.	8 drs.	5 drs.
24-bore	8½drs.	6¾drs.	4¼drs.
28-bore	8½drs.	6¾drs.	4¼drs.

The scale in the Act of 1855, like that in the Act of 1813, applied to rifles as well as smooth-bores; but there is one important point of difference between the two. The old Act simply laid down the regulation that a gun taking a lead bullet of 12, or 13, or 14 to the pound, or whatever the bore might be, should be tested with a definite quantity of powder. In those old muzzle-loading times a gun was numbered in correspondence with the weight of the bullet which would pass down the barrel; and if the bore were too narrow to admit a ball of 12 to the pound, it would be numbered 13 or 14, according to the ball which it would take. The new Act, however, departed from this simplicity by not only defining the diameter of the bore which would take balls of a given number to the pound, but also by stating the size and weight of the bullet to be actually used in proof; and in every case (no matter whether it were a punt gun with a bore 2in. in diameter, or a small-bore of half an inch in diameter) the ball for proof is 20-thousandths of an inch smaller than the nominal bore.

This, too, is on the supposition that the guns are really of the bore they are represented to be. Such, however, is very commonly not the case; for the Act does not say how the measurement is to be taken, and the law is construed in a way which enables gunmakers still further to weaken the test. With boring machinery that will work to the thousandth of an inch, there is no difficulty in running very close to the legal boundary without over-stepping the mark; and in this way a considerable addition is made to the wide margin already allowed by law. The gun is thus submitted to a less severe test, and the maker consequently runs less risk of diminished profits by the bursting of his barrels in the proof-house. The risk to the user of the gun is left out of consideration.

The practical result of this arrangement may be seen in this way:—The actual diameter of a 12-bore is ·729 inch, of a 13-bore ·710 inch, and of a 14-bore ·693 inch; but if the barrel gauges a fraction less in diameter than is here stated, it is classed as the next size smaller. Hence a barrel which is the veriest trifle under ·729 would be classed as a 13-bore of ·710; and, as the Act makes a reduction of 20-thousandths in the size of the proof-bullet, the gun is accordingly tested with a bullet of ·690. Here, then, would be a gun, ordered by the sportsman as a 12-bore, and used by him with the cartridges, wads, powder and shot of a 12-bore, but nominally proved as a 13-bore, and with a proof-bullet not quite so large as one of 14 to the pound, or two sizes less than the practical gauge of the gun. In a similar way the proof-bullets for other bores would be considerably smaller than the bore itself—those for 16 and 20 bores being two sizes less, and those for 28-bores being four sizes less.

The Act of 1868, so far as the scale of proof-charges for shot-guns were concerned, remained as in the Act of 1855, but an entirely new scale was substituted for rifles. The powder was reduced in the proof of rifles larger than 20-bore, but the lead was increased; whereas for bores under 20 the charges of powder and lead were increased, and for all gauges from 24 to 50 bore (about ·577 to ·450) the proof-charges were alike, so that the length of the leaden plug used to prove a ·450 rifle is nearly four times its diameter, and its weight is about six times as great as the ball allotted for the proof of a shot gun of equal diameter.

Under such circumstances as these, how is it possible that the proof of the gun should be as satisfactory as it ought to be? Not only is the ball of light weight, but it offers no resistance in the barrel; and, the wads being also less than the bore, they neither resist movement, nor prevent the escape of the gas.

When the gun is actually finished, and delivered over to the purchaser, it is not improbable that, in the process of fine-boring and regulating, the bore of the gun may have become of the full size ordered, although it was not so at the time when it underwent proof. Thus, Major McClintock, in the course of some experiments with shot-guns, which he described in the *Field* about two years ago, found that several of the guns he used were larger in bore than accorded with the proof-marks. As is commonly the case with nominal 12-bores, they all had the "13" proof-mark on them; but this is what Major McClintock said with respect to their actual diameter:

According to the Proof Act, a 13-bore has a diameter of 0.710", a 12-bore a diameter of 0·729", and an 11-bore a diameter of 0·751"; but it will be noted that the following barrels, although marked "13," were in reality 12-bores:

	Right barrel.	Left barrel.
	inch.	inch.
No. 1 Gun	0·749	—
No. 2 ,,	0·732	0·730
No. 6 ,,	0·730	0·729
No. 9 ,,	0·737	0·741

These barrels were no doubt correct to gauge when marked, but have become enlarged by careless cleaning, or lapping out to remove rust, &c. The right barrel of No. 1 gun was lapped out to its present size by a local gunmaker, to remove a surface flaw in the bore.

Whatever may have been the case with No. 1, there can be little doubt that the others were virtually 12-bores from the first, but were kept just within the margin in order to avoid the heavier proof-charge, and, when the process of proof had been passed through, any slight alteration in the bore would take them beyond the boundary. "Tricks of the trade" are no novelties. The late Mr. W. Greener, half a century ago, inveighed in strong terms against the evasions and falsifications of proof that were practised in those days; and it is very satisfactory to find his son, at the present time, following in his father's footsteps, by endeavouring to impress upon the Birmingham Proof-House authorities the necessity of making their regulations more efficient. The late Mr. Greener, in his book on "The Gun," published in 1835, said:

The provisions of the Act are evaded in the following manner. I have already mentioned that the London Company passed a bye-law requiring all double barrels to be soldered together before they are proved. This is without doubt a beneficial arrangement, were it only strictly enforced. I know, however, that since so many of the London makers now get their barrels from Birmingham ready for stocking, many barrels are sent from the latter place to the former for proving, which, when returned, are taken

to pieces, and reduced on the outside several ounces, and then re-soldered with brass, instead of, as they were before, with tin. This process, in addition to what they have already suffered by "sweating," as it is called, reduces their strength still further to the extent of full 15 per cent.; and, if they have been hammer-hardened, to 30 per cent. If they have been proved in Birmingham, they have generally to be reduced on the part intended for the jointing together, or inside under the rib, in addition to the double injury they have already sustained by sweating and brazing. After this comes the boring of a full size out of them, by what is termed fine boring; and even after this, they are likely to be bored again to improve their shooting; so that if the sporting charge be only two-thirds as great in pressure as the proof charge, the barrels are not likely to bear it after all this sweating, reducing, brazing, boring, and re-boring, by which the strength *after proof* is reduced full 45 per cent.

How far practices of this kind are current at the present time is a matter upon which it would be desirable to have some definite information. It certainly looks as if the existing rules of proof have a tendency to encourage evasion of the legal proof-charge in one respect; and on another point there is a question which naturally suggests itself after reading the above extract. We have heard a good deal of late about the danger arising with steel barrels if they are over-heated in brazing; but if the barrels are duly brazed before proof, and if the proof is as efficient as it ought to be, how is it that the overheated barrels withstand a severe official ordeal, and then burst with a comparatively small charge in the hands of the sportsman? When these guns are submitted to the definitive proof, have they been brazed at all, or are they merely stuck together temporarily with solder? Does the present rage for light barrels induce the makers to pare them down in a similar way to that described by Mr. Greener half a century ago? And is the gun proved with extractor and everything complete, as it goes into the sportsman's hands, or is the metal cut away for the extractor afterwards? I have seen several burst 20-bores lately in which the rupture undoubtedly commenced at the extractor pin-hole, where the metal was so much cut away that it seemed scarcely possible that the gun could have withstood proof, unless that proof were little more than a legal sham.

It seems to me that the present scale of proof for shot-guns might be swept away with advantage, and the scale for rifles applied, with the simple alteration that No. 6 shot should in all cases be used in testing the smooth-bores, whether in first or second proof. The charge of powder would thus be lessened in proving most shot-guns, but the proportion of lead would be increased, especially in powder in first proof and 150 per cent. in second proof. Under these conditions, a 12-bore pigeon gun constructed to carry 4drs. of powder and 1¼oz. shot would first be proved with 8drs. of powder and nearly 2oz. of shot, and in the second proof it would have the same quantity of shot with 6drs. of powder; whereas a light 12-bore, whose ordinary charge was 3drs. of powder and 1oz. of shot, would have 6drs. and 4½drs. respectively of powder in the two proofs, with 1¼oz. of shot in each case.

If a 20-bore were constructed so as to compete with a 12-bore by carrying 1oz. of shot, it should be proved accordingly; and supposing its powder-charge to be 2½drs., it would be tested with 5drs. of powder and 1¼oz. of shot in first proof, and 3¾drs. and 1¼oz. of shot in the second. The stamp on the barrels should indicate the charge for which the gun is proved, as "3drs., 1oz.," and not the amount used in proof. It would be as well, I think, also to stamp the actual weight of barrels at final proof, so that a pair of scales would at any time show if there had been any material reduction of substance. But I doubt the necessity of continuing the present stamps to distinguish choke-bores from cylinders, if all are submitted to the same test.

The wads, however, should be tight wads—not, as now, often considerably less than the actual bore. In the old Proof Act nothing was said about wads; but according to the late Mr. Greener the practice in 1835 was as follows:

> On the quantity of powder given in the scale, is put a ball of lead of the size of the bore. It is customary to put between the powder and ball a roll of paper, and on the ball a second roll. These have the property, owing to their construction, of expanding when struck by the copper rod that is used for the loading, and, by fitting the bore completely, are calculated to be of great advantage by increasing the friction.

In the Act of 1868, however, the wads prescribed for smooth-bores are to be of felt, cork, or paper; and Mr. W. W. Greener, in his recent book on "The Gun and its Development," says that cork wads are used at Birmingham. Whenever, as has been previously shown, a virtual 12-bore is proved as 13-bore, these cork wads must necessarily be loose in the barrel, so that "the great advantage by increasing the friction" must now be lost. It is customary nowadays to use tight wads in loading cartridges; and guns which have been proved as 13-bores are, in actual use, loaded with wads some of 12-bore and others of 11¾. It seems to me essential that tight wads should be used in proof, otherwise much of the gas must escape, and, mingling with the shot, will tend to drive out the pellets in a straggling fashion without producing anything like the amount of resistance which occurs in the gun in ordinary use. It should not be forgotten, too, that there is no turned-over cartridge in proof; at present the guns are loaded from the muzzle. It may be worth consideration whether cartridge cases could not be introduced, so as to assimilate the proof as nearly as possible to ordinary conditions of use. At all events I think that tight wads should be imperative; and that they should be at least 5-thousandths of an inch larger than the diameter of the bore—such diameter being ascertained by actual measurement, and not assumed according to the process of putting a 12-bore in the 13 class.

The kind of gunpowder to be used ought also to be more clearly defined. In the Act of 1855, as in that of 1813, it was stated that "the gunpowder used for proof shall be of equal quality and strength with that which is now used by the Honourable Board of Ordnance." In the Act of 1868 it is altered to "equal quality and strength with that which is now used *or from time to time shall hereafter be used* by Her Majesty's Government." This ought to be satisfactory if properly carried out; for, as was said by Major (now Colonel) Majendie, in his book on "Arms and Ammunition," published about a dozen years ago:

> We believe that we may safely affirm that there is no powder in the world equal to that which is produced at the Government Mills at Waltham Abbey, unless it be the powder which is turned out from the mills of some of the leading English makers, such as Curtis and Harvey, Hall and Sons, Pigou and Wilks, and others.

And some years previous, Major Mordecai, of the U.S. army, after carrying out most exhaustive experiments, had recommended that the process of manufacture which was pursued in the English mills at Waltham Abbey should also be adopted by the American government.

The proportion of ingredients used in our Government powder is the same now as when the first Proof Act was passed; but of late years various improvements have been made in matters of detail and adaptation of grain to particular purposes. When the Act of 1855 came into force, the only powders mentioned in an official pamphlet relative to the process of manufacture at Waltham Abbey were L.G. and F.G. (large and fine grain); but now (1885) there are R.F.G., R.F.G.², R.L.G.², besides pebble, prismatic, &c. Accordingly, it is desirable that the regulations should define which kind is to be used, and that arrangements should be made whereby powder of the determined quality should be purchased from Government, so as to prevent any doubt as to its quality. That the Government does at present sell gunpowder is obvious, because in addition to there being several varieties manufactured, as above enumerated, the powders are also classified with respect to condition, according as they are new or old, or damaged in store; and Class V. consists of such as are "condemned for sale," being "gunpowder found too much deteriorated for any of the first three classes, and for which a market can be found." Now, supposing, after such powder had found a market it should by any chance also find its way into a proof-house, in one sense it would be powder of the same quality as used by Her Majesty's Government, but it certainly would not comply with the spirit of the Act as regards its strength. Accordingly, it is desirable that the powder used for proof should be supplied from the actual service stores of the Government, simply out of regard for public safety.

It appears from the letter of the Clerk to the Gunmakers' Company, that in the London Proof-house "the same quality and strength of powder have been used for the last twenty-five years." This does not show a compliance with the terms of the Act, but the reverse. If, however, it were proved that the same quality of powder had been used for a much longer period, that would not be evidence of the powder being originally good. Here is what the late Mr. Greener wrote on this subject in 1841:

> The gunpowder used is of a very inferior description indeed, when compared with sporting powder; the very powder all sporting guns are to be used with is nearly three times the power of the proof powder. . . . Compare the resistance of 1¼ ounces of shot, a body capable of being jammed together, and thus exerting a lateral pressure of the greatest extent, with the lateral friction of two rolls of paper and a solid ball not capable of any lateral extension, and barely, all weighed together, equal to two-thirds the weight of the charge of shot, and the dissimilarity becomes glaringly apparent. The proof powder is quite unfitted for the purpose. The generality of barrels that do burst [in proof] are all rent in the fore part; the guns that burst with shooting burst near the breech—I do not say all, but a vast majority. This is in perfect keeping with all my remarks; for in sporting, the greatest test is the first lift of the charge; in proving, the greatest test is in the mid distance from breech to muzzle, and so arises the result. . . . The proportion of guns that are broke (they technically call bursting *broke*) in proving is very small, not exceeding 3 or 4 per cent. This I also applied to headquarters to know; but, like the

answers to the other questions, I was left to guess at them. The largeness of the grain of the powder is at too great an extreme; no doubt it is beneficial to have larger than the present sporting scale [No. 2 or even No. 1 was then commonly used], yet here they have grain large enough for a duck gun, instead of appropriating it to the various purposes wanted. . . . If the Legislature does not take up the question, and, by the institution of a suitable test, backed by a penalty commensurate with the crime of depriving a fellow creature of his limb, it will neglect an imperative duty, and become a *particeps criminis*.

Fortunately, it is not now absolutely requisite to occupy the time of the Legislature in order to obtain a proper proof of guns, for by the joint action of the Government and the Proof-house authorities, the rules and scales of proof may be altered when they are found insufficient. The Government possesses, in Her Majesty's Inspectors of Explosives, highly efficient officers, who have done good service in looking after the public safety in other ways; and they would put sportsmen under a considerable obligation, if they could adopt some means of saving the limbs, or even the lives, of owners of guns, by securing for the weapons a more reliable test than is at present in force. T.

[Since the above article was published, various amendments have been made in the rules of proof, for which see pp. 2 to 8.—ED.]

THE DIVERGENCE OF PROJECTILES FROM DOUBLE-BARRELLED GUNS.

(*Field*, Dec. 1, 1888; Vol. 72, p. 806.)

SOME interesting correspondence has recently been published in the *Field* relative to the influence of the cast-off of the stock, the laying together of the barrels, and other effects of a more or less important character, in causing projectiles to diverge from the

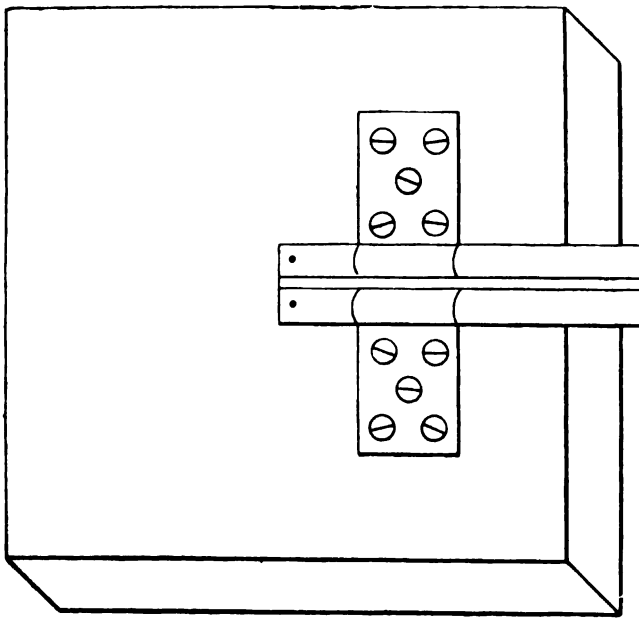


FIG. 1.

apparent line of aim. And as I happen to have carried out some experiments which appear to throw a little light upon the subject under discussion, I propose to lay the results before your readers.

The reason that the two barrels of a shot-gun or rifle will, if they are put together with the bores perfectly parallel, throw their charges in diverging lines has, in my opinion, never yet been satisfactorily accounted for, although many plausible and ingenious theories have been advanced for the purpose. It would very naturally be supposed that the divergencies resulted from the axes of the barrels not being in the same vertical plane as the central line of the stock; but that this is not the true explanation will, I think, be proved by the results of the experiments which I am about to describe.

The illustration which is first given (Fig. 1) represents a pair of rifle barrels put together parallel, and firmly fixed to a very heavy block of hard wood. This block of wood was backed up so as to entirely prevent recoil. On testing this arrangement by firing the respective

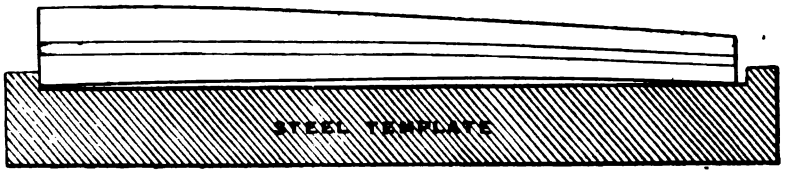


FIG. 2.

barrels at a target, it was found that at a distance of 100 yards the bullet from the right-hand barrel struck the target 10in. to the right of the centre of the bullseye at which the barrel was aimed; and that the bullet from the left barrel struck the target a corresponding distance to the left of the bullseye.

The pair of parallel barrels were now taken out of the block; the ribs were taken off, and the muzzles brought together in the usual way. The result was that very good shooting was now obtained from the converging barrels—the other conditions of the trial being the same as before.

In the next experiment, a ·500 Express double rifle, fitted with a cross-eyed stock, was tried at the target, and, although both sights were fixed very nearly in the centre of the rib, excellent shooting was obtained.

Now, in the first two experiments recoil was not allowed, the block which served as substitute for a stock being practically immovable. Under these conditions (if the generally received theory were correct) the parallel barrels should have thrown their charges in parallel lines; instead of which they were 20in. apart at the end of 100 yards. In the second experiment, with the muzzles converging together, the two lines of fire should have crossed each other; instead of which the projectiles from the two barrels struck the target very close together.

With regard to the trial of the cross-eyed rifle (which has a cast-off of three inches), it was expected that, if three-sixteenths of an inch of cast-off produces the effect on the flight of the charge which some people imagine, the consequence of using this gun would literally be to "shoot round the corner." Fixing the back sight on the right barrel, and the front sight on the left, was what was originally contemplated; but, as a matter of fact, the rifle was finished with the sights nearly in their usual positions; and yet, as already mentioned, excellent shooting was obtained.

The next step was made with a view to discover the actual cause of the divergence resulting from the first-mentioned experiment. A single barrel was now taken, to which a template was accurately fitted, in order to serve as an indicator of its exact length. The barrel was then subjected to a heavy internal hydrostatic pressure; and under this treatment the barrel expanded circumferentially, and at the same time was reduced in its length. This result, it was considered, gave a clue to the solution of the problem.

An ordinary pair of barrels were now taken, and a template was fitted to the side of the right-hand tube. As the template exactly fitted the barrel when the tube was not subject to internal pressure, any alterations in the length or contour of the barrel that might ensue on the application of pressure could readily be noted by a comparison with the template. All being in readiness, the right-hand barrel was then subjected to internal hydrostatic pressure, and the result is shown in an exaggerated form in Fig. 2, where it will be seen that both barrels are bent into an arched form. This effect would be produced by the barrel under pressure becoming expanded circumferentially, and thereby reduced in length, because the metal that is required to supply the increased circumference is taken to some extent from the length, although the substance of metal in the walls of the barrel, by its expansion, contributes also to the increased diameter. Upon relieving the internal pressure, the barrels resumed their original form.

In order to still further confirm the above experiments, the barrels of an ordinary 12-bore gun were securely fixed at the extreme breech

and muzzle to a table or rest (Fig. 3). A number of loose blocks of wood (marked A A A on drawing) were placed on the table at intervals, so as nearly to touch the side of the left barrel. Upon the right barrel being fired the pieces of wood were thrown violently aside—thus showing that the left barrel must have sprung outwards owing to the shortening of the right-hand one, and by the breech and muzzle not being able to move. A corresponding effect would be produced on firing the left barrel, the curvature being then in the opposite direction; and, as the projectiles passing through the barrel would follow the direction of the curve, the shot would diverge to the right when the right-hand barrel was fired, and to the left, in a corresponding degree, when that barrel was discharged.

HORATIO PHILLIPS.

OBSTRUCTIONS IN GUNBARRELS.

(*Field*, Aug. 2, 1885; Vol. 66, p. 282.)

SIR,—I ask leave to print in the *Field* a reference to a statement on p. 205 of "The Modern Sportsman's Gun and Rifle," Vol. II., viz., "At all events, it is not correct to assume that obstructions in the barrel invariably cause bursting, for there are many facts to prove the contrary. Some instances are mentioned at page 398 of the

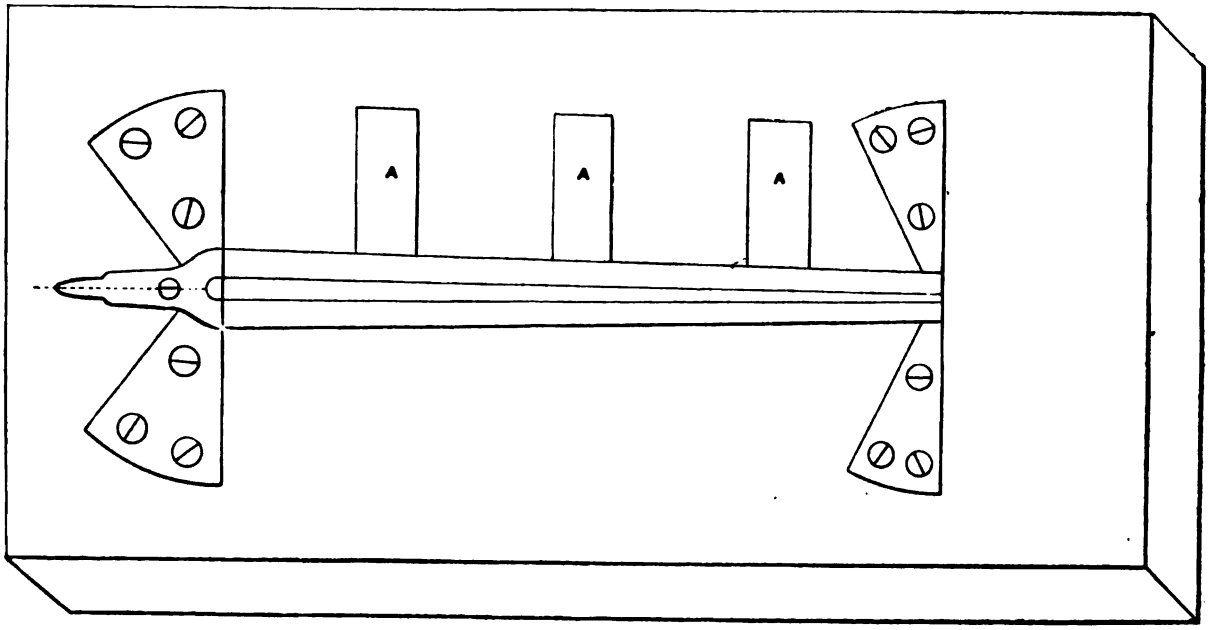


FIG. 3.—DIVERGENCE OF PROJECTILES (see opposite page).

previous volume. Experiments have also been carried out on behalf of the U.S. Government, and it was found that of a large number of army rifles purposely choked with sand, &c., only a very small percentage were burst."

I know of no one who asserts that when we fire a shot gun, a musket, or a rifle, loaded as usual, which has its muzzle obstructed with such a substance as sand, for instance, "bursting" will "invariably" take place; but the language of the book leads the reader greatly to under-estimate the danger of ruining the weapon. I would be obliged to any military or other reader who can prove that "experiments" "carried out on behalf of the U.S. Government"—or any other Government—ever showed that when ordinary rifled muskets, "purposely choked with sand, &c.," were fired, "only a very small percentage were burst." Obstructions, such as sand, mud, snow, and "stuck" bullets are very dangerous. Moist sand, for example in the muzzles of our Springfield rifled muskets can be relied on to ruin the weapons in a very large percentage of cases.

WM. MCKENDREE HEATH, late Captain 5th Ohio Cavalry.

Philadelphia, Pa., July 4, 1885.

[That guns have been burst owing to the charge being fired while the barrel was choked by mud, or some other obstruction, is well known. Instances of the kind have been mentioned in the *Field* from time to time; but they have been few and far between. They neither occur so often, nor are they so necessary a sequence of obstruction in the barrel, as many people imagine. It is by no means an uncommon belief that a barrel so choked will invariably burst, and numerous quotations might be made to show this, if necessary; but it will suffice to give the following: In 1879 a paper was read before the Royal Society of Edinburgh, by Professor G. Forbes, in which he said: "It is well known that, if an ordinary fowling-piece, charged with shot or ball, have touched the ground or snow, so as to close the muzzle of the gun, or if the muzzle be in any way artificially closed with grease or other substances, the fowling-piece *is certain to burst* at the muzzle when it is discharged." Again, Mr. J. D. Dougall, the well-known gunmaker, in his book on "Shooting, its Appliances, &c.," says: "The most frequent cause of a gun bursting is the stoppage of the muzzle by snow or earth, which, though apparently easily dislodged, *will burst the strongest barrel*. The whole of that part of the barrel in front of the stoppage is usually blown clean away. It is not required that the stoppage be complete; even if very slight, the mischief will be done." As far as we are aware, Mr. W. W. Greener was the first to dispute the accuracy of the assertion that such stoppages always burst the gun. In his book on "The Gun and its Development," he says: "*It has always been taken as an axiom* that if the muzzle of a gunbarrel be by any means plugged up with dirt, snow, or other matter, and the gun then fired, the gun will burst. It has also been repeatedly asserted that a wad slipping a few inches down the barrel, or left from a preceding charge, would burst the barrel should it be fired before the impediment was removed. We have experimented to prove these assertions, and find them far from being true." Then follow particulars of experiments, in one of which an inch was blown off the muzzle of a barrel that was choked with stiff mud, but in all his other experiments the barrels remained uninjured; and Mr. Greener concludes by saying: "Now we are willing to own that we have attributed several burst barrels to wads slipping and muzzles becoming plugged up, but we shall be less liable to state these as causes in future. Barrels do sometimes burst in the most unaccountable manner, but from these experiments it appears that wads slipping will not cause them to do so as a rule, and plugged muzzles are not always attended with disastrous or dangerous results." We may add that some experiments which we ourselves carried out several years ago were quite confirmatory of the conclusion arrived at by Mr. Greener. The statement with reference to experiments in the United States was founded on information published, about two years since, in an American journal—it is believed that it

was either the *American Field* or *Forest and Stream*; but, as the extract cannot now be found, the exact particulars cannot be given. The following extract, however, from a report ("Ordnance Notes," No. 117) made by Capt. Greer, of the U.S. Ordnance Department, in September, 1879, may be of interest: "Two condemned barrels were taken at random from a lot turned in from the field. Eight or ten rounds were fired from each of them, rags of various sizes having been inserted in the bore, a little below the front sight, without affecting the barrel the slightest. Sand next having been inserted in the muzzle, the barrel was shaken so as to remove all but a few grains which adhered to the fouling; the piece was then fired. This was repeated several times without swelling the muzzle. The barrel was then run into wet sand, and the bore nearly filled for about an inch and a half. After firing in this condition the barrel was found swelled at the muzzle, precisely like those that have been received from time to time from the field. Several pine plugs from six to eight inches in length were then prepared of a size to fit the bore closely. The second barrel was fired twice with the plugs driven in dry, about one-half their length, twice driven in wet, and twice driven in dry but afterwards swelled with steam, both inside and outside, without injury to the barrel. The inclosed air probably forced the plugs out before the bullets reached them. A plug was then split in two to represent a broken tompion, the air being free to pass by the plug. It was thought that the bullet might wedge on the remaining side of the plug, but the barrel was found uninjured after the shot was fired. Occasionally a cup anvil of the Frankfort service shell has been found in the barrel after firing. It was thought possible that one of these might become wedged in the barrel and cause the swelling. To test this question an anvil was driven down squarely across the barrel just opposite the front sight. The piece was then fired without injury to the barrel. A second anvil was driven down to the same position, but obliquely to the axis of the bore. No damage resulted from the firing. A long wad of cotton waste was then wetted and rolled into a spiral, and forced down the barrel several inches by the ramrod. The piece was then fired, when the barrel was found swelled a little beyond the wad, which was probably carried forward a few inches before the bullet wedged upon it." So far as the extract goes (for we have not the entire report) no mention is made of a barrel actually bursting; but bulging occurs in some cases and not in others, and wet sand appears to be one of the most likely substances to procure such a result. Probably, however, the difference between bursting and bulging would in many instances be due to the difference in texture of the metal from which the barrels are made.—ED.]

(*Field*, Oct. 23, 1886; Vol. 68, p. 609.)

SIR,—I read the letter of your correspondent F. C. A. with great interest, as I have made many experiments to determine whether guns could be burst by wads left or placed in the barrel. The conclusion at which I arrived was that a gun of ordinary strength could not be so burst or injured.

I have to-day repeated some of these experiments, using a much honey-combed gun of my make, which has had some six years' hard wear; the barrels 12-bore, 30in. long, and weight 3¼lb. I find that a charge of 4 grains of E.C. powder and the usual wadding, and 1⅛oz. of shot, will usually put the shot clear of the barrels, but that the powder wads remain at or behind the choke in the barrel. The shot is thrown about twenty yards, but has not force to penetrate a sheet of brown paper at seventeen yards. Schultze powder gives like results. A charge of black powder of equal bulk will throw the shot and wads clear, penetrating one sheet of brown paper at seventeen yards, and making a good pattern at forty yards if the proper elevation be given to the gun; 3 grains, by measure, of black, throws the shot clear, but not, in every instance, the powder wads; 2 grains by measure give results akin to 4 grains by measure of Schultze or E.C. powders.*

When the wads were left in the barrel I fired a full-charged cartridge, loaded with E.C. or Schultze, and 1⅛oz. of shot, and in every case the wads were blown out without the barrel being burst or in any way injured.

I also tried placing tightly-fitting felt and other wads in various parts of the barrel, putting as many as four altogether, tightly jammed at the choke. Also several wads, a few inches being left between them; but I could not injure the barrel by any of these methods.

Sometimes the 4grs. of E.C. would not move the charge of shot, even so far as the choke; and, in one instance, with only 2grs. of E.C., the wads were a little upheaved, and the turned over end of the cartridge uncurled a little to allow the gas to pass, but the charge of shot had not stirred. I tried 1½drs. of black powder and 1oz. of shot in the barrel in which 4grs. of E.C. had left the wads and charge of shot, and the barrels were effectually cleared, but not in the least injured. I tried again, under similar circumstances, with 42grs. of E.C. powder and 1⅛oz. of shot, and the barrel burst at 14in. from the breech, the charge of shot in this case being loose between wads at 12in. from the breech, and 6in. from the muzzle.

I tried the remaining barrel with a charge of shot, 1⅛oz., placed between two wads, about 1in. in front of the chamber, and fired 42grs. of E.C. and 1⅛oz. of shot from it, but this did not in the least injure the barrel of action—which proves that even a well worn barrel, however light, if sound, of good English metal and properly constructed, will stand an enormous strain, and be safe with any sporting charge.

I repeated this last experiment, putting the charge of shot between wads at 9in. and 7in. from the breech respectively. The barrel burst at 10in. from the breech. This pair of barrels I have sent to your office for inspection.

I am afraid I have not been able to assist F. C. A. to a correct conclusion. If I can prevent him from arriving at a wrong one I shall be pleased, for I am convinced that no barrel should burst because a wad obstructs the bore. I am also certain that no one could fire so small a charge as 4grs. without being aware of it. When the charge of shot is left in the barrel there is no smoke from the muzzle, no report, and no recoil. It is, therefore, almost impossible that this could have happened three times, or even once, to F. C. A. without his being aware of it.

The metal lining in cartridge cases supports the wad, and with a small charge, such as 4grs., the ramming in of the wad would not show the deficiency to the loader, and with some machines it is quite possible for individual cases to escape without any powder. This want of uniformity will always constitute a danger to the users of these cartridges.

W. W. GREENER.

Birmingham, Oct. 20, 1886.

(*Field*, Oct. 30, 1886; Vol. 68, p. 653.)

SIR,—I regret not being able to complete these experiments in time for your last week's issue, as they appear to me, taken with those by Mr. Greener, to fully corroborate the opinions expressed by yourself and F. C. A. as to the cause of guns bursting.

I inclose a table of sixteen shots, with their charges and results, fired by myself in the presence of another person. All the charges were carefully weighed and load with *Field* loading, the wads being only pressed down to the same distance at that allowed by a 42gr. charge of E.C. In every instance it will be noted the whole charge was thrown well forward into the barrel, leaving the cartridge case entirely, and, when not projected beyond the muzzle, there was invariably a slight escape of gas observed at the breech joint, with but little report or noise. The barrels used were best Damascus, cylinder bored, of which one tube had been shortened nine inches through a burst some months ago. They were rather light forward, but in very sound condition. The first twelve experimental shots were fired from the left or full-length barrel, the remainder as described. Though there was no choke to obstruct passage, the *Field*, thick felt, and card wads used between powder and shot (the former 11½ size) form a very stiff obstruction in the barrel.

The barrels may be seen here at any time, or I shall be pleased to forward them to view at your office. Evidently something more than wads must obstruct to always burst barrels.

85, Edgware-road, Oct. 27, 1886. FREDERICK BEESLEY.

Results of twelve experimental shots fired by F. Beesley, using the undermentioned charges of E.C. powder, thus: one 11½ *Field* wad, one ⅜ thick felt, one thin card; 1⅛oz. No. 6 shot; thick card over, and well turned down; barrels 12-bore cylinder; and four further shots, with obstructions in barrels as below:

No. of Shot.	Charge of E.C. in grains.	Results.
1	1	3 wads 14in. from breech; shot wad 8in. from muzzle; all shot loose in between.
2	1	3 wads 15in. from breech; shot all clean out of barrel.
3	2	3 wads 16in. from breech; shot wad 10in. from muzzle; shot in between.
4	2	3 wads 21in. from breech; shot wad 5in. from muzzle; shot in between.

* We conclude that "3 grains by measure" of black powder represents a quantity equal in bulk to 3 grains of E.C. or Schultze. If so, the actual weight would of course be about 6 grains, the specific gravity of black being about double that of the nitro-compounds.—ED.

No. of Shot.	Charge of E.C. in grains.	Results.
5	3	3 wads 16in. from breech; shot wad 9½in. from muzzle; shot in between.
6	3	Whole charge and all wads went clean out of barrel.
7	4	3 wads stopped 7in. from muzzle, shot going clean out.
8	4	3 wads stopped 18in. from breech; shot wad 4in. from muzzle; shot between.
9	6	3 wads stopped 5in. and 7in. from breech; shot went clean out of barrels.
10	6	Whole charge went clear out of barrel.
11	8	Do. do. do.
12	8	Do. do. do.

13. With 3 powder wads jammed 3in. from muzzle, a full charged E.C. cartridge cleared barrel entirely, without the least sign of injury. Left barrel.

14. With felt and thin card 3in. from muzzle, space of 3in., then *Field* wad jammed, and 6in., the fully-charged cartridge cleared the barrel as above without injury. Left barrel.

15. After firing 2gr., shot wad stuck at 5in. from muzzle; felt and field at 9in. from muzzle; shot loose in 4in. space between; with full charge, barrel burst. Left barrel.

16. Other barrel treated the same as preceding shot, burst when fired with full charge at 14in. from breech, where the barrel is pretty stout. Right barrel.

(*Field*, Nov. 6, 1886; Vol. 68, p. 660.)

SIR,—As several theories have been quoted to account for the bursting of barrels by E.C. and Schultze powders, for my own satisfaction I have been trying a few experiments, the result of which I beg to transmit you, and as none of your former correspondents have given any record of the flight of the shot or the recoil (with the several charges), perhaps this may be interesting to some of your readers. A gentleman suggests that a portion of the powder being left unexploded until reaching a distance up the barrel may be the cause of fracture. I have given this theory a severe trial, without any detriment to the barrel. My experiments have been tried with one of my light 12-bore guns (weight of barrels 2lb. 15oz., 26in. long). All shots were fired from the shoulder, so as to make the condition as nearly as possible like the bursting of the guns of your correspondent. The target was at 40 yards, and the right barrel (cylinder) used.

Experiment No. 1, four rounds, with 42grs. of Schultze.—21grs. were placed in cases with no projecting lining; 1¼ *Field* wad, tilted at an angle of about 45°; usual pressure; then the other 21grs. with 1¼ felt and usual pressure; 1⅛oz. shot and card; the case coiled. I noticed brilliant sparks at the muzzle, slight recoil, low report, more smoke than usual, and a few pellets weakly struck the bottom of the target. The four shots gave similar results.

Experiment No. 2, four rounds, with 42grs.—21grs. with thin black card and usual pressure; then 21grs., 1¼ *Field* wad, and usual pressure; 1¼ felt, 1⅛oz. of shot and card; case coiled. More recoil, louder report, and smoky; a few pellets weakly struck the target at the bottom. The four shots gave similar results.

Experiment No. 3, three rounds, with 42grs.—21grs. in case, usual pressure, without wad; felt and *Field* wad placed in the barrel 12in. from the breech; 1⅛oz. shot and wad on the top; then 21grs., gently rammed next to *Field* wad. Much louder report, smoky, low recoil, and a few pellets scattered over 3ft. target, weak. The three shots gave similar results.

Experiment No. 4, three rounds, with 42grs.—This experiment was the same as in No. 3, with the exception that 14grs. were loose in the bottom of the case and 28grs. gently rammed next to the *Field* wad. Results similar to the preceding experiment. The gun apparently hung fire in each instance.

In the foregoing trials my object in dividing the powder with tilted wad was for the second division of powder to ignite at a thin part of the barrel; but it gave no ill results. I then divided the powder by a thin black wad, which allowed the second portion to iguite; but evidently it was not sufficiently consumed to give increased force to the shot. From this, I conclude, that if any portion of the charge got caked, it would not injure the barrel by exploding in the weakest part; for unless the whole charge of powder is exploded in the case, it does not develop sufficient force either to burst a barrel, or drive the shot with the necessary velocity. The next series gave the following results:

Experiment No. 5, First shot.—Felt and *Field* wad, placed 9in. from the breech; shot wad 9in. from the muzzle, with 1⅛oz. shot loose between. A cartridge (loaded with 43grs. and 1⅛oz. shot, *Field* and felt wads) being fired, produced heavy recoil, loud report, and scattered pattern on 3ft. target.

Second shot.—Wads and shot in same position in barrel; cartridge loaded as before. Heavy recoil, loud report, and barrel bulged 10in. from breech (under side).

Third shot.—Same loading as above; same barrel. Heavy recoil, loud, ringing report, and barrel burst 16½in. from breech (under side), or 6½in. beyond the bulge.

From the above, and other experiments, I have no doubt in my own mind that the cause of the accident to your correspondent's guns was deficiently-loaded cartridges. Had cases been used without the inside lining, which forms a shoulder on which the wads lodge (and hand-loaded), it would be almost an impossibility for one cartridge dangerously deficient of powder to pass the loader's hands without detection. The only thing I cannot understand is, that the gentleman did not notice that there was no report or smoke from his previous discharge.

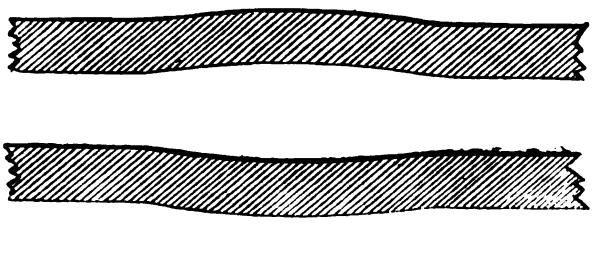
I send you the barrels I have been experimenting with.

Birmingham, Nov. 3, 1886. LINCOLN JEFFRIES.

(*Field*, Dec. 25, 1886; Vol. 68, p. 919.)

SOME weeks ago we published a number of letters from correspondents relative to the bulging or bursting of gunbarrels, and the probable effect of wads and shot being left in the gun when imperfectly loaded cartridges are used. It may possibly be remembered that one gentleman, who had had three barrels injured by bursts or bulges, found, on opening a large number of the cartridges which he was using, that some among them contained only a tenth of the ordinary charge of powder, or even less. They had been loaded by a machine which was not in proper working order, and which had dropped into some of the cases too little powder for use, but quite enough for mischief. The owner of the guns (F.C.A.) fired some cartridges containing a similar quantity of powder (4grs.), and found that it sufficed to drive the shot charge and wads to just that part of the barrel where the other guns had been burst or bulged. The inference was obvious; and Mr. Greener, in the following week, gave it a practical application by trying various experiments, which showed (*Field*, Oct. 23, 1886) that when the obstruction consisted of wads alone, it was readily removed by the charge which followed, without damaging the gun; also that, when both wads and shot were left in the barrel, they were driven out when followed by only a *light charge* (1½drs. and 1oz.), but that the *full charge* (3drs. and 1⅛oz.) caused the obstructed barrel to burst. It may be inferred, therefore, that the small charge of powder pushed on the shot so slowly that the gradually compressing column of air was able to impart sufficient motion to the obstructing mass to prevent damage being done: but that the velocity produced by the full 3drs. did not allow time for the stationary charge to be pushed out of the way, while the pellets would be jammed together by the force behind, until the smash came. Besides Mr. Greener's experiments, others were carried out by Mr. F. Beesley and Mr. Lincoln Jeffries [and here published in the two preceding pages], and these likewise showed conditions under which guns would or would not burst; so that a good deal of practical information was thus laid before our readers.

Subsequently we requested Mr. Griffith to carry out some experiments in his crusher-gauge apparatus, with the view of ascertaining, if possible, what amount of pressure was developed by the first charge of shot and wads being left stationary in the barrel, and thus obstructing the passage of the second charge. One of the results of these experiments will be seen by the following illustration, which



represents the effect produced on a solid steel barrel, about 4in. from the muzzle. In a previous impression (see page 297), we gave a representation of the breech end of this barrel, where the steel is an inch in thickness; but after going about 6in. beyond the end of the chamber the thickness of the barrel is reduced, and it tapers off to about a quarter of an inch at the muzzle. At the point where the bulge occurred the steel is $\frac{3}{32}$ of an inch thick, as shown in this illustration. A charge of No. 6 shot (1⅛oz.) had been placed between

wads about 2ft. from the breech, and, on a similar charge being fired with 3drs. of powder, a bulge of about an inch and a half in length was produced. Mr. Griffith writes: "The obstruction lay at 6in. from the muzzle; the bulge commences at 5in., and has a centre at 4½in. So the obstruction began to move, by pressure of compressed air, when the charge started, and was caught up by the advancing charge at about 4in. from the muzzle. The intervening air, being so compressed, the walls of the barrel gave way. It is a singularly striking instance of the value of the contained air in the barrel."

It will not appear very surprising, when a steel barrel of such thickness is bulged in this manner, that ordinary gunbarrels should succumb under a similar strain. We have seen some burst barrels in which the metal had been so much cut away that it was only about a tenth of the thickness of this steel barrel. What was the actual pressure at the bulge could not be ascertained, as the three crusher-gauges were far from the point of collision.

Mr Griffith tried similar obstructions at various distances from the breech; but the steel being thicker at those points, no visible effect was produced; while the strain was so local that no very material variation was produced upon the crusher-gauges, although the nearer to them the obstruction was placed, the greater was the pressure on the third plug, and in a less degree upon the second, except in the last instance, at 6in., when, the obstruction being over the third plug, there was a slight diminution at the third and an increase on the second, as will be seen by the records here given. The illustration showing the crusher-gauge apparatus will be seen at page 29; but we may here state that the first plug is 1in. from the breech, the second 2¾in., and the third 6in. The obstruction in the barrel consisted of a tight *Field* wad, thick felt and card wad, then 1½oz. of No. 6 shot, with a card wad over the shot, as in the ordinary loading; and it was so placed that the *Field* wad was at the specified distance from the breech. The following were the pressures per square inch at the three plugs when the barrel was clear, and when it was obstructed:

	First Plug.	Second Plug.	Third Plug.
	lb.	lb.	lb.
Without any obstruction	1835	1907	1058
Obstruction 24in. from breech.....	1820	1907	1076
,, 18in. ,, ,, ...	1832	1900	1114
,, 12in. ,, ,, ...	1805	1918	1132
,, 9in. ,, ,, ...	1826	1930	1147
,, 7in. ,, ,, ...	1835	1977	1290
,, 6in. ,, ,, ...	1850	2030	1266

[The actual pressures were probably much higher, as explained in the articles on crusher-gauge experiments, pages 30 and 32.]

The above numbers were all of them averages of several shots. Mr. Griffith adds: "I quite think, with a near obstruction, that this and the charge begin to move together, and increase the pressure but a little—only forming, in fact, an extra heavy charge, and the small space between acting to reduce pressure, if anything. But when some distance intervenes, allowing the charge to acquire some velocity, it bursts the gun by suddenly compressing the air between the advancing charge and the obstruction—this, of course, being an obstruction which forms an air-tight plug in the barrel; and for any bursting arising from a slight obstacle in the barrel not air-tight, we must look to the check on free delivery of gas and the pressure set up thereby, on the hydraulic ram principle." The velocity of the shot, so close to the breech, would necessarily be very much lower than when it has nearly reached the muzzle, and the strain would doubtless be vastly increased by the additional speed. It would be a matter of considerable interest if a crusher-gauge could be fitted near the muzzle, so as to obtain a record of the strain at that point.

G.—T.

FURTHER EXPERIMENTS WITH OBSTRUCTIONS IN GUNBARRELS.

(*Field*, April 6, 1889; Vol. 73, p. 466.)

A NUMBER of letters have appeared in our columns with reference to guns having burst under circumstances which, if correctly stated, are certainly very mysterious; and we have tried a few experiments with the view of endeavouring to solve the mystery. We did not, for our own part, imagine that the accidental presence of a wad would be likely to have caused the mischief; the experiments carried out by Mr. Greener, Mr. Beesley, and Mr. Lincoln Jeffries (as reported in the numbers of the *Field* for Oct. 23, Oct. 30, and Nov. 6, 1886) were far too clear and explicit to admit of our entertaining any doubt upon that point. But we thought it desirable to try one or two experiments which were not included among those above alluded to, and we now have to report the result.

We commenced with obstructing the end of the barrel with wads, for the purpose of ascertaining, in the first place, whether the gun, (which was a stub twist of about the ordinary strength) would pass through this ordeal satisfactorily; for, unless it did so, it would be valueless as a test of what we believed would produce a much greater strain. The cartridges used were loaded with 3 drams C. & H. No. 4 powder, and 1⅛oz. No. 6 shot, with the usual wads.

To commence with, a tight-fitting felt wad was placed in the barrel at its weakest part (*i.e.* about six inches from the muzzle); a charge was then fired, and the wad was blown out without doing the slightest injury. The trial proceeded by gradually increasing the number of wads, and blowing them out in the same way. Eventually there were seven wads (four felt and three cloth) tightly jammed in the barrel, and these also were blown out without injury to the gun.

Pieces of the paper cylinder of 12-bore cartridge cases were next thrust up the barrel to various distances from the breech end; but, when the gun was fired, they likewise were invariably driven out without doing the slightest damage. The paper of a 16-bore cartridge case (the largest that would go in) was then driven into the muzzle, and the brass base cut off; this was also blown out without affecting the barrel.

Finally, the muzzle of the gun was dipped into some soft garden mould, which stopped up the bores for a length of 1½ inches. This mould was so loose that the mere weight of an ordinary wooden cleaning rod was sufficient to push the earth out of the left barrel. The right barrel, however, was fired with the mould *in situ*, and the result was that the forward part of the barrel became a total wreck—one piece, nearly three inches long, and about half the circumference of the barrel, being blown right away, and the extreme muzzle split open. The main portion of the burst extended from 1½in. to 4½in. from the muzzle.

In this case the mould apparently acted in the same way as the sand tamping used by miners when blasting rock, *i.e.*, it would tighten itself by the sudden pressure put upon it. The air imprisoned between the front wad and the tamping would increase in pressure as the charge advanced, until the barrel or the tamping gave way.

Now, the conclusions which we draw from these experiments are, that there is no probability of a gunbarrel of ordinary strength—or, indeed, anything which deserves to be called a gunbarrel—being burst from a wad being left behind, or by the paper base or "cork" of the cartridge case being, through any defect, driven up the barrel.

Also, there appears to be little or no probability of the paper cylinder of the cartridge case causing danger if it become separated from the brass end. At all events, in every instance in our experiments in which a paper cylinder was thrust into the barrel, the wad in front of the shot swept away the obstruction. Neither the wads nor the paper cylinder seem to take any "grip" on the walls of the barrel. But when the obstruction consists of some loose substance which becomes impacted by the sudden application of force, then a burst or bulge ensues.

The experiments of Messrs. Greener, Beesley, and Jeffries all showed burst barrels with shot between the wads; and Mr. Griffith showed that, under similar conditions, a steel barrel was bulged though more than a quarter of an inch in thickness. Our own experiments go to show that, while a succession of seven wads, nearly two inches in length, were driven out as a single cork would be, a mass of soft earth of less dimensions was not expelled, but it was doubtless squeezed together and consolidated, and at the same time would cling tightly to the barrel. Probably the same thing would happen with moist snow; unfortunately none of this was available, or we would have tried the experiment; but, certainly many instances have been reported of bursts being caused by snow, although we have had no opportunity of investigating them.

This week a correspondent has sent us a sealing-wax impression of the muzzle of a gun, which had been bulged through a jag covered with oiled tow being left in the barrel. Here the tow around the metal jag doubtless became impacted owing to the pressure produced by the advancing bullet, and a bulge was the result.

Several years ago, the late Mr. Walsh inadvertently fired a gun before removing a wooden stopper several inches in length, which he had placed in the muzzle; but here the material was incompressible, and, as it had no hold on the barrel, there was nothing but its weight to overcome, and it was blown out without damage.

It may be said, however, that none of these experiments clear up the mystery around the particular instances of bursting which have led to the discussion. But the more completely the imaginary causes of such accidents are exhausted, the stronger become the grounds for assuming that a well-known and effectual means of bursting was in operation although the owner of the gun was wholly unaware of the fact.

Not long ago we saw the broken end of a pair of barrels where there were signs of soil remaining as obviously as in the gun we burst this week, and yet the owner had no idea that he had touched the

muzzle against the ground. In another instance, we had a strong impression that there was earthy matter, but several months had elapsed since the accident occurred, and in the absence of a microscope it could not be determined with certainty whether it was mould or not. In another instance, that we were told of, the owner of the gun was very positive that his gun had never touched the ground, until the marks of the barrels were shown to him.

It is very possible, when the mind is concentrated on something else, that the shooter may, in dropping the barrels for reloading (especially if he be a little man with full-length barrels), or in getting over a bank, or jumping across a ditch, inadvertently let the muzzle come into contact with the soil, and yet be perfectly convinced that he never has done so. This has happened again and again, and will doubtless be repeated again and again; and it seems to us that such inadvertence is far more likely to be the cause of the accidents in question than any of the suggestions which will not stand the test of experiment. P.—T.

(*Field*, April 13, 1889; Vol. 73, p. 503.)

SIR,—I was most pleased to see your last article on obstructions in gunbarrels. I am sure there will be many who will read it with more than common interest. You seem to have experimented with wads in such a way that there ought to be no doubt for the future of the impossibility of their doing the damage to guns which is now being discussed.

I suppose it is useless my stating again how certain I am the muzzle of my gun went nowhere near the ground, comparatively. All who have read your article, and also the letters of your correspondent Mr. F. Beesley, will say I am, and must be, mistaken. I shall certainly start next season with a much less fear of a similar accident recurring to me.

I may mention the day that my gun burst was rather wet. I should like very much to know if a wad remaining in the barrel, and becoming damp, would be blown out of the barrel by the next discharge as easily as a perfectly dry one? I should think it would be more likely to stick. I do not, however, myself think that much, if any, wet could have got down my barrels, as there was so short a time between the shots. I must say I am inclined to believe a wet wad would be much less likely to be blown out of a barrel, without doing damage, than a dry one.

I must thank you for having taken up this subject, and for having experimented in the way you have done. The result, I feel sure, many men would not have credited, unless backed up by such authority as yours. P. H. R.

[We soaked five felt wads in water, and placed them in the weakest part of the left barrel of the gun, the right barrel of which was burst by the earth being put into it as described in our article of last week. On firing an ordinary cartridge, the five wet wads were driven out without doing the slightest injury to the barrel. We can readily understand our correspondent's belief that he did not touch the ground, because we have known other instances in which the conviction has been equally as strong. Nevertheless, as far as we can judge from circumstantial evidence, we cannot but think that, when he killed a bird with his first barrel, and reloaded before another bird came up, his attention may have been diverted for the moment, and, the ground having been unconsciously touched with the end of the barrels, some earth got into the muzzle of each; and then, on firing a right and left, both barrels were burst. Last week, when we touched the ground, the earth got into both barrels, and if we had fired two cartridges instead of one, we have no doubt the result would have been to leave the gun in just the same condition as that of our correspondent.—ED.]

NICKEL STEEL FOR MAKING GUNBARRELS

(*Field*, June 1, 1889; Vol. 73, p. 764.)

A HIGHLY interesting paper on Alloys of Nickel and Steel was recently read before the Iron and Steel Institute by Mr. James Riley of Glasgow, and we propose to draw attention to a few facts which were brought to light during the reading of the paper, and the discussion which followed.

Ordinary mild steel, such as is used for gunbarrels, would bear a strain of about 30 tons per square inch; but the elastic limit of such metal would be closely approached by a strain of only 15 tons. We need scarcely remind our readers that a strain well within the elastic limit of a metal may be applied an indefinite number of times without injury, because, when the strain is relieved, the metal will resume its original form; but, if this limit is exceeded, permanent set commences, and ultimate failure is inevitable. Hence it will be obvious that a high elastic limit is a very desirable quality for a metal which is to be used for the construction of guns.

Let us now see what effect a small admixture of nickel has upon steel in raising its elastic limit and breaking strength. Mr. Riley took a mild steel, containing 0·22 per cent. of carbon, and alloyed it with 4·7 per cent. of nickel, with the result that the elastic limit, which had been 16 tons, was raised up to 28 tons, and the breaking strength was increased from 30 to 40·6 tons. More extraordinary still, this great accession of strength was obtained without impairing the elongation or contraction of area to any noticeable extent. When, in addition to the above, we state that nickel steel is harder, will take a finer polish, and is not so corrodible as ordinary steel, it will be seen that it is a very valuable metal indeed.

In opening the discussion, Mr. J. F. Hall, the manager of Jessop's works at Sheffield, stated that it was with mixed feelings he rose to speak on the subject before the meeting. When he first saw the title of the paper on the programme he was taken all aback, but it was evident that Mr. Riley had been pursuing a parallel line of investiga-

tion to that in which he had himself been engaged for some time past. Mr. Hall said he had made some thousands of experiments, but he certainly should have said nothing about them yet had not his hand been forced, as he did not consider the matter had been thoroughly thrashed out. He had, however, made nickel steel into gunbarrels, and had, amongst others, presented a 12-bore double-barrel fowling piece to the chairman of his company. The weapon had been made by Messrs. Holland and Holland, who had previously tested to destruction a barrel of the same kind. A number of tests were made with the nickel steel barrel, which ultimately gave way when 15drs. of powder and 3¼oz. of shot were used, with double wadding. The maker of the gun said that he never could have imagined the material would have stood such a test.

The illustration given above represents the breech-end of the nickel steel gunbarrel alluded to, which was tested to destruction; and the way in which the ribbons of metal have curled up, without breaking, is ample proof of the very high quality of the metal

employed. It was a 12-bore barrel, but has been reduced to half-scale in the woodcut.

Mr. Hall said that he had made nickel steel possessing a tensile strength of 97 tons, and over 7 per cent. elongation. That was the highest he had been able to get, but he thought it ought to content everyone.

EXPANSION AND CHOKE OF GUNBARRELS.

(*Field*, Sept. 3, 1892; Vol. 80, p. 371.)

We were recently testing at the target a 12-bore single gun, the barrel of which was very light forward, and the metal was not thickened up towards the muzzle, as is usually the case with shot barrels. The bore was practically cylindrical. We were using 42grs. of nitro powder and 1¼oz. of No. 6 shot, yet the pattern did not average 100 pellets in the 30in. circle at 40 yards. It occurred to us that probably the shape of the exterior of the barrel had something to do with the inferior shooting; and a ferrule of metal was therefore slipped over the muzzle, and soldered thereon. Upon again trying the gun at the target, it was found that the thickening of the metal at the muzzle, by means of the ferrule, had increased the pattern from less than 100 to an average of about 130 pellets.

The cause of this great increase of the pattern was due to the wave of expansion (as it travelled up the barrel) being suddenly checked by the increased thickness of metal at the muzzle—thus converting for the instant a cylinder barrel into a slight choke.

The next thing to do was to ascertain to what extent expansion took place in an ordinary cylinder barrel during the passage of the charge. For this purpose, delicate gauges were fitted to the muzzle, and also to the thinnest part of the barrel—situated 6in. from the muzzle. Upon firing the gun with the usual charge, it was found that the extreme muzzle only expanded ·003 of an inch, whereas the thinner metal, 6in. from the muzzle, expanded ·012; so that, during the passage of the charge, the barrel was converted from a cylinder to a slight choke having ·009 of an inch contraction—the difference between the two amounts of expansion; hence the closer pattern.

The fact that a cylindrically-bored barrel becomes a slight choke while it is subjected to internal pressure recalls many memories of the past in connection with boring barrels for shooting, and throws light on some of the dodges resorted to by the old time rule-of-thumb barrel borers.

Many sportsmen will doubtless be surprised to learn that their cylinder barrels are actually chokes when in use; and that the shape of the exterior of a gunbarrel has an important influence on its shooting qualities.

P.

AN EXTRAORDINARY 12-BORE GUN.

(*Field*, Dec. 12, 1891; Vol. 78, p. 894.)

It is not often that one has an opportunity of examining and experimenting with a gun of a length that was used by our great-great-grandfathers, but fitted with all modern improvements; and, hearing that Mr. Charles Lancaster had been building a 12-bore breechloader of very extraordinary dimensions, for a gentleman living in South America, we requested to be allowed to give the gun a trial, in order that we might compare notes with the results obtained by short barrels, of which we had published lengthy particulars.

The barrels of this gun (which is intended for duck shooting) are a fraction over 45 inches in length, chambered to receive an ordinary 12-bore cartridge, taking from 3drs. to 3½drs. of powder and 1⅛oz. or 1¼oz. of shot. The weight of the gun is 8lb. 10oz.; so that, while the length of the barrels is 50 per cent. greater than is ordinarily used nowadays, the weight of the weapon is about 23% higher than that of a 7lb. gun. Both the barrels are moderately choked, and give a pattern of about 190 pellets of No. 6 in a 30in. circle.

At the early part of the century, Colonel Hawker (who looked upon 30in. barrels as very short) said that "a short gun, at a short distance, will kill as well as a long one, yet the latter will give you a more accurate aim, and considerably lessens recoil." The fact that this gun gives comparatively little recoil is beyond question. It is remarkably easy on the shoulder; and can be handled with much more facility than one would expect from its great length. The diminution of recoil is, of course, in some measure due to the increased weight of the gun; but that is not the sole cause of the difference, as will be explained further on.

As the gun is to be sent to South America with 200lb. of E.C. powder and 100lb. of Schultze, we gave it a trial with these two nitro powders, in charges of 42grs. and 45grs., the shot charge being throughout 1⅛oz. of No. 6. We likewise tried 3drs. and 3½drs. charges of C. & H. No. 2 and No. 6, in order to compare the effects of the fine and coarse grain in the long barrel; but the owner of the gun does not use black powder. Three rounds of each series were fired, and the average results in muzzle velocity and recoil were as follows:

	3 drs.	3½ drs.
E.C. powder—Muzzle Velocity	1123 ft.sec.	1227 ft.sec.
,, *Recoil*	*19·4 ft.lb.*	*22·9 ft.lb.*
Schultze—Muzzle Velocity	1116 ft.sec.	1251 ft.sec.
,, *Recoil*	*19·6 ft.lb.*	*23·5 ft.lb.*
No. 2 Black—Muzzle Velocity	1202 ft.sec.	1273 ft.sec.
,, *Recoil*	*28·5 ft.lb.*	*31·5 ft.lb.*
No. 6 Black—Muzzle Velocity	1071 ft.sec.	1144 ft.sec.
,, *Recoil*	*24·3 ft.lb.*	*26·6 ft.lb.*

The velocity with the smaller charge of the nitro powders differs but little in the 45in. barrel from what was given by the 30in. barrel. With No. 2 black, however, there is a considerable increase; but the coarse-grain black powder made a much smaller advance than we had expected from the long barrel. With the larger charge of powder the velocity throughout was considerably greater than it would be with 30in. barrels, and the increase with the nitros was larger than with the black powders. The recoil was generally low; but the differences will be better seen by comparing the records shown by 3drs. charges in the long gun, with others that have been previously published, of the same powders and charge, in a 30in. barrel. In all instances, in the following table, the recoil is represented as that of a 7lb. gun, in order to facilitate comparison. This is effected by calculation as regards the 45in. barrels—the amount of recoil varying in inverse proportion to the difference in weight of the two guns; for the 30in. and 34in. barrels, the figures given are the same as were published in the *Field* of Aug. 29, 1891.

	30in. barrel.	34in. barrel.	45in. barrel.
E.C. Powder (42grs.):			
Muzzle Velocity ...	1106 ft. sec.	1120 ft. sec.	1128 ft. sec.
Recoil ...	*26·7 ft. lb.*	*25·2 ft. lb.*	*23·9 ft. lb.*
Schultze (42grs.):			
Muzzle Velocity ...	1113 ft. sec.	1119 ft. sec.	1116 ft. sec.
Recoil ...	*26·9 ft. lb.*	*25·1 ft. lb.*	*24·2 ft. lb.*
No. 2 Black (3drs.):			
Muzzle Velocity ...	1122 ft. sec.	1147 ft. sec.	1202 ft. sec.
Recoil ...	*33·2 ft. lb.*	*33·2 ft. lb.*	*35·1 ft. lb.*
No. 6 Black (3drs.):			
Muzzle Velocity ...	1051 ft. sec.	1094 ft. sec.	1071 ft. sec.
Recoil ...	*27·0 ft. lb.*	*27·6 ft. lb.*	*30·0 ft. lb.*

It will be observed that, with E.C., there was a slight increase of velocity with each increase of length in barrel, but a decrease in recoil. With Schultze there was very little difference in velocity, whether the barrel was 30in., 34in., or 45in. long; but with each increase in length the recoil fell off. With No. 2 black there was an addition to recoil with the 45in. barrel, but not in proportion to the increase of velocity. With No. 6 black, in the long barrel, the velocity dropped off a little, and recoil increased. The cause of this we cannot satisfactorily account for; we can only say that it was not one isolated occurrence only, but was repeated in three successive rounds. The smaller proportion of recoil with the other powders we did expect, after the results obtained in various previous experiments; for when the barrel exceeds a certain length (varying more or less with different powders) the decreased pressure of the powder gases barely suffices—and in some cases does not suffice—to counterbalance the constant amount of friction of the charge in the barrel; but the friction is overcome by the momentum of the shot, which thus to some extent drags forward the barrel as it progresses, and thereby lessens the recoil.

P.—T.

CURIOUS ACCIDENTAL EXPLOSION OF CARTRIDGE.—The following may be of interest to your readers. When ferretting this week I had occasion while standing on a bank to throw a cartridge bag to my brother. It fell between 4ft. and 5ft. on to soft grass, when one of the cartridges exploded—blowing a hole in the bag. I send you the case. Can you account for the explosion? It is evident that cartridges should be handled more carefully than one is accustomed to do.—R. E. M. Russell (Massbrook, Lahardane, co. Mayo, Jan. 11, 1896. [The cartridge case bears evidence of having received a sharp blow, the rim being indented upon one edge. The concussion would tend to move the anvil laterally, and thus produce sufficient friction to explode the cap. We have known instances of cartridges exploding with less concussion than the one above alluded to appears to have received.—Ed.]

THE GUNS OF OUR ANCESTORS.

(*Field*, March 30, 1889; Vol. 73, p. 428.)

A GOOD deal of correspondence has appeared in the *Field*, from time to time, with reference to old-fashioned guns and their shooting capabilities—the long shots made with small charges of fine-grained powder, the specialities of boring of celebrated gunmakers who flourished in the early part of the present century, and other matters respecting which it was difficult so say how much of the many stories told in good faith might be relied on as actual records of fact, and how much was due to the mysterious halo developed from the mists of antiquity. Circumstances have lately arisen which afford a means of clearing away some of the mists, and placing the facts in distinct relief; for several gentlemen who are possessors of ancient guns have very kindly placed them at our service, for the purposes of inspection and trial.

The more immediate cause of the trial about to be described was the correspondence in which a prominent part was played by Mr. J. Wolfe Murray, who forwarded us a 20-bore gun by Dickson, which he used in his boyhood, and which he thus describes: "I send you my first gun, with which I shot in 1827. My father, Lord Cringletie, a Scotch judge, gave it to me. He was one of the best shots of his day, and shot with a flint gun all his life. He had the gun converted to a detonator; but the suddenness of the fire startled him, and he could not shoot with it. I tried it at 40 yards, a 2ft. circle; it shot hard, not very close, but put pellets well into the bullseye (about 3in.), four with one and three with the other. I shot 2drs. fine grain, and 1oz. No. 6 soft shot."

Another correspondent ("20,000 Shots") sent us four guns—two with flint locks, and two with percussion. One of the flint guns, a single barrel, was made by "Segalas, London." We have not been able to trace the name of Segalas, but "20,000 Shots" thinks the gun is probably about a century and a half old, and his grounds for entertaining this belief are as follows:

"The reasons that induced me to think it about 150 years old are various. Cheek-pieces on the stock, which went out of use in my recollection (you have an instance in the Harding single I send you) were introduced to fowling-pieces I think about 1770; now this Segalas gun is without, and the formation of the stock, the long hollows under the comb, induce me to think this gun is antecedent to cheeks. Again, the broad and very shallow pan (which is lined with gold), the great fall of the hammer, and the filing of the cock all point to the same early period; further, the single guns of 1780 to 1800 were mostly much more bell-mouthed than this. There is a singular arrangement of the fore-end that I have never before seen, but I think this probably was a means resorted to to repair an accident to it. Again, the peculiar silver mountings opposite the lock, and the thumb-plate denote great age. An old friend of mine (aged 83) declares his belief that it is the same gun that belonged to a friend of his father's when he was a lad of ten; it was then supposed to be sixty or seventy years old. He pronounces it one of the celebrated Spanish barrels. Although with a very short toe and 31in. of barrel, this gun mounts and handles quite as well as many modern guns. Query, whether our ancestors did not know more about this than most people give them credit for?

"On the silver thumb-plate is a very fair representation of a pointer standing his game, beneath which is the word 'Cave.' Whether this was the name of the original owner of the gun, or whether it represented the Latin adage 'cave canem,' I cannot say. Perhaps it might be intended to convey the old words of caution, 'take heed.' When I was a boy it was a common thing to run three, four, or more dogs together. On one setting his game, the keeper invariably called 'To-ho,' following it up with 'take heed'—the former to give notice to the other dogs to stop and back; the latter, addressed to the pointing dog, not to 'draw on' his game. In these days, when partridges are so highly educated in the art of taking care of themselves, one has to 'take heed' in another way, for the old course of procedure would put every covey to premature flight. I often think how birds used to lie in the strong stubbles fifty or sixty years ago, waiting complacently for the sportsman to walk in before the dogs tread them up, and what an easy business it then was to shoot them, in spite of the 'click-fizz-bang' of the old flint locks. Doubtless some of our ancestors, who were considered cracks in their day, would cut but a sorry figure if they could be spirited back for a few days' modern bird shooting. Within my recollection birds would lie better to dogs at Christmas than they now will on the 1st of September.

"There is certainly a vast difference in the shooting of the present day. The whole thing is so completely changed within my memory that I feel certain guns thought well of when I was a boy would not now be carried by any keen sportsman—40 yards then being considered the extreme limit for a clean kill, anything much beyond being looked at with wonder; whereas, before my sight became affected, I could, with full-choke guns, kill as certainly and regularly at 60 yards as I had previously been able to do at 40; in fact, no difficulty lay with the choke gun—it was all in the time-allowance necessary for the shot to arrive at this distance."

It seems not improbable that "20,000 Shots" is correct in his conclusion that his "curio" is a century and a half old. At all events, we went back 149 years in the vain endeavour to find the name of Segalas in ancient volumes of London Directories, which date as far back as 1740. In the search for Segalas, however, we met with better-known names, and we may mention that in the volume for 1796 we first found John and Joseph Manton entered among the tradesmen of London—Joseph having his shop in Davies-street, Berkeley-square, while John had his in Dover-street, Piccadilly. But Joe had taken out patents for improvements in guns four years before his name appears on the list of London tradesmen. At the time these patents were taken out (1792) he was about twenty-six years old. Joe and John do not appear to have been on very amicable terms. An action, "Manton v. Manton," arose out of Joe's patent for an elevated top rib taken out in 1806; and the patent was invalidated, on the ground that guns made on that principle were in existence before the date of the patent.

To return, however, to the immediate purpose of the present article, "20,000 Shots" likewise sent to us for inspection and trial a fine old double flint-lock gun of 16-bore, by Mortimer, of Ludgate-hill (a well-known maker mentioned by Colonel Hawker early in the century); another was a 20-bore double gun by Joe Manton, that had originally had flint locks, but had been converted to a detonator; and the fourth was a 16-bore single percussion gun, made for the brother of "20,000 Shots," about sixty-five years ago, by Harding, of Blackman-street, Borough, and reputed to be a remarkably good gun to kill.

Among the flint guns sent for trial was an 11-bore double gun made by the late Charles Lancaster, and lent to us by his successor in the business. This gun (which was exhibited at the International Exhibition, Hyde Park, in 1851) is a fine specimen of workmanship. It was made for Sir Richard Sutton, about half a century ago, and used in a pigeon match at the Red House, Battersea. When fine-grain powder was used with this gun, sufficient was carried through the touch-hole by the air from the barrel, to fill the pan; but when used with coarse grain, a separate priming with fine grain had to be given.

Last, but by no means least in interest, were two guns lent by Mr. Peter Hawker, grandson of the celebrated Colonel of the same name. Both of these guns were made under Colonel Hawker's personal superintendence—one by Westley Richards, and the other by Burnett of Southampton; the latter was afterwards re-bored by Charles Lancaster. We likewise received from Mr. Hawker a rifle that belonged to his grandfather; but this weapon we did not try.

As a good deal has been said of late about the boring of guns, we had the internal measurement of the barrels of the shot guns carefully taken throughout their whole length; and the results were as follows:

FLINT GUNS.

SEGALAS SINGLE 11-BORE (the property of "20,000 Shots").—Length of barrel, 32in. Diameter of bore at breech ·736, at 18in. from breech ·725, then cylindrical for 4in., then relieved to muzzle, where the diameter is ·744.

MORTIMER DOUBLE 16-BORE (the property of "20,000 Shots").—Length of barrels, 30in. Diameter of bore—*Right Barrel*: Very nearly cylindrical, being ·654 at breech, and gradually reduced to ·653 at muzzle. *Left Barrel*: ·649 at breech and for next 17in., then gradually relieved to muzzle, where it is ·652.

DOUBLE 11-BORE, BY CHARLES LANCASTER.—Length of barrels, 31in. Diameter of bore—*Right Barrel*: ·753 at the breech, decreasing to ·751 at 29in. from the breech, the remaining 2in. being cylindrical with this diameter (·751). *Left Barrel*: ·753 at breech, decreasing to ·751 at 3in. from muzzle, these 3in. being cylindrical with ·751 diameter.

PERCUSSION GUNS.

DICKSON DOUBLE 20-BORE (the property of Mr. J. Wolfe Murray).—Length of barrels, 27¼in. Diameter of bore—*Right Barrel*: ·611 at the breech, and ·610 at half an inch from the breech, then continuing cylindrical for 6in. with the last-mentioned diameter, after which it opens out slightly, and is ·612 at the muzzle. *Left Barrel*: ·614 at the breech and ·610 at half an inch from the breech; for the next 5in. it is cylindrical with ·610 diameter, and then, like the other barrel, opens out to ·612 at the muzzle.

HARDING SINGLE 16-BORE (the property of "20,000 Shots").—Length of barrel, 27⅞in. Diameter of bore, ·670 at the breech, gradually decreasing to ·664 at 21⅜in. from the breech; and then, in the remaining 6in., it opens out to ·671 at the muzzle. No part is a true cylinder.

JOE MANTON DOUBLE 20-BORE, converted from flint to percussion (the property of "20,000 Shots").—Length of barrels, 31in. Diameter of bore—*Right Barrel*: ·600 at the breech, diminishing to ·599 at 10in. from the breech, and then continuing cylindrical with the last-

mentioned diameter for the next 18in.; in the remaining 3in. it opens out from ·599 to ·607, which is the diameter at the muzzle. *Left Barrel:* ·601 at the breech, and ·600 at 9in. from the breech; then cylindrical for 13in. with last-mentioned diameter; and in the remaining 9in. it opens out from ·600 to ·607.

WESTLEY RICHARDS DOUBLE 12-BORE (the property of Mr. Peter Hawker).—Length of barrels, 31in. Diameter of bore—*Right Barrel:* ·714 at breech, diminishing to ·707 at 26in. from breech, and then relieved to the muzzle, where it is ·720. *Left Barrel:* ·712 at breech, reduced to ·706 at 26in. from breech, and then relieved to the muzzle, where it is ·720. There is no part cylindrical in either barrel.

BURNETT DOUBLE 12-BORE (the property of Mr. Peter Hawker).—Length of barrels, 33in. They were re-bored by Charles Lancaster, and their diameters are as follows—*Right Barrel:* ·725 at breech, diminishing to ·723 at 24in. from breech, then cylindrical for 6in., and afterwards relieved to the muzzle, where it is ·730. *Left Barrel:* ·725 at breech, and reduced to ·723 at 27in. from breech, next 3in. cylindrical, and then relieved to muzzle, where it is ·727.

Before carrying out the general trial, we made a great many preliminary experiments, with different charges, variations in grain of powder, differences in wads, &c., in order to see what would produce the best results. Mr. Wolfe Murray told us that he had been in the habit of using 2drs. of fine grain powder, which, from the sample sent to us, appeared to be No. 1.

"20,000 Shots" informed us that he and his brother had been in the habit of using 2drs. or 2½drs. of C. & H. Treble Seal fine-grain powder, with 1¼oz. to 1½oz. of shot. From Messrs Curtis and Harvey we learnt that this powder corresponded with the No. 1 Treble Strong of the present day, but that when it bore the old designation, about half a century ago, it was packed in paper packets, which eventually gave way to the tin canisters now universally adopted.

The Charles Lancaster flint gun had been shot with "Lancaster's special grain," a coarse powder, about No. 5 in grain, and requiring a separate priming of finer grain powder to ignite it. This we tried, as well as some modern powders, such as "basket grain;" but we could not find that anything suited the old guns better than No. 1. Some other grain might put a few more pellets on the target, with a little less penetration, or *vice versa;* and so with increased charges of powder—the extra quantity scattered the shot, and spoilt the pattern, though a little extra force was shown. Eventually, therefore, we came to the determination to adopt the same powder (No. 1 T. S.) for all the guns, 2drs. being used with 1¼oz. of No. 6 shot, irrespective of size of bore; and this had one advantage, at all events, viz., of not producing confusion by variations in the charges. When loading the flint guns, 2drs., and as much over as would fill the pan, was used, because the powder that passed through the touch-hole to act as priming did nothing towards the propulsion of the shot.

As to wadding, we tried various kinds, both ancient and modern. It may, of course, be said that many felt and other wads now in use had never been seen by our ancestors; but that was no reason why the old guns should be debarred from using them if they gave any advantage, especially when put in comparison with modern guns that have this advantage. "20,000 Shots" told us that he doubted whether anything would suit his guns better than brown paper, and it was tried accordingly. But punched wads are not so recent in their origin as many people imagine; and this will be made obvious on reading the following extract from "The Art of Shooting Flying," a book written about a century and a quarter ago, by T. Page, gunmaker, of Norwich:

Friendly.—What sort of wadding do you best approve of? I have heard some say that tow is best; others cards stamped to fit the size of the bore.

Aimwell.—Tow, I think is uncertain. If cards be used, the end of your rammer must be almost as broad as the barrel will admit to go down free, and quite flat at the end, to prevent the card turning; and must be pushed down gradually to give time for the air to pass, otherwise it would be troublesome. This is therefore not the quickest way. Old hat may be used in the same manner, which is rather better; and some say leather shreds are best. But I cannot yet find anything better or so ready as thin brown paper rubbed soft, and cut into pieces about one inch broad and two inches long, so that when doubled it is an inch square.

Doubtless many among the oldest of our readers well remember wads being punched out of the old beaver hats that were in general wear half a century ago; but they would probably never have imagined that old hats were used in the same way in the middle of the century before they were born.

Perhaps some of our readers may think we were overdoing the old 16-bores and 20-bore guns by giving them 1¼oz. of shot; but let us see what Mr. Page says was the practice in his time:

It is a common practice in this country to load with a pipe bowl of powder and a bowl and a half of shot; and when they find they can't kill often, they think they don't put shot enough, so put more. . . . . I put in equal measures of powder and shot, which in weight is nearly 1 to 7. To a barrel of a middle-sized bore, whose diameter is about five-eighths of an inch, which I look upon to be the best size for shooting flying [this would be about 19 or 20-bore, in modern parlance], I put in two ounces of shot, No. 4, which are about 200 in an ounce, and an equal measure of powder.

Mr. Page evidently knew a good deal about guns, and he discusses scientific matters, such as Robins's investigations at Woolwich, in a manner that would astonish many a modern gunmaker, who may be amused on learning that there is an advertisement at the end of the book which states that "T. Page, Norwich, makes and sells watches, clocks, jacks, pullies, birding guns of various lengths, bores, and prices, pistols, crossbows, all sorts of machines for strengthening the weak or lame, or making extension of broken limbs, steel trusses for ruptures, best double strong gunpowder, gunflints," and other articles too numerous here to particularise.

We must, however, get back from the past to the present, and say that we tried brown paper between powder and shot in these old guns, also a cloth wad was tried; but the best results were obtained with a thick felt wad between powder and shot, and a cloth wad on top of shot. An extra cloth wad was used over the shot in the left barrel, to prevent the charge becoming loose when the right barrel was fired. In these experiments two shots were fired out of each barrel, so as to warm the gun before the trial commenced; and then eight shots were fired from each, and the best six were recorded, as it was necessary to reject some of them in consequence of "balling" being prevalent; and in some cases, extra shots had to be fired to make up the required number of six. Messrs. Curtis and Harvey most courteously provided the powder required to carry out the trial with the nearest approach possible to the old order of things, and also placed their chronograph at our service to record the results; while Mr. Brown, the manager of the works, took great pains to secure satisfactory records, although his patience must have been sorely tried while the "click, fizz, and bang" part of the performance was going on, with a considerable percentage of misfires. The chronograph records are the mean velocities for the 40 yards range. The results with the respective guns were as follows:

SEGALAS SINGLE-BARREL FLINT GUN.

Pattern in 30in. circle.		Force on Gauge.		Pellets on 10in. plate.		Force per pellet.
110	.....	15	+	12	=	1·25
137	.....	16	+	14	=	1·14
114	.....	18	+	15	=	1·20
112	.....	16	+	15	=	1·07
120	.....	15	+	12	=	1·25
114	.....	18	+	12	=	1·50
118	.....	Average	.....			1·23

The velocity by chronograph was under 640 feet per second, which is the lowest that Messrs. C. & H.'s scale records. This gun balled three times during the trial.

MORTIMER DOUBLE-BARREL FLINT GUN.

Right Barrel. Pattern.	Gauge.		10in. plate.		Force.	Left Barrel. Pattern.	Gauge.		10in. plate.		Force.
121	39	+	22	=	1·77	130	31	+	17	=	1·82
130	29	+	18	=	1·61	120	27	+	17	=	1·59
117	34	+	20	=	1·70	130	41	+	24	=	1·71
140	38	+	22	=	1·73	137	33	+	19	=	1·74
131	27	+	19	=	1·42	148	39	+	20	=	1·95
160	29	+	18	=	1·61	111	22	+	14	=	1·57
133	Average				1·64	129	Average				1·73

Average velocity by chronograph, right barrel, 736 ft.sec.; left, 740 f.s. This gun balled once, nearly the whole charge being in three clusters.

LANCASTER DOUBLE-BARREL FLINT GUN.

Right Barrel. Pattern.	Gauge.		10in. plate.		Force.	Left Barrel. Pattern.	Gauge.		10in. plate.		Force.
162	40	+	27	=	1·48	150	37	+	20	=	1·85
170	42	+	24	=	1·75	122	30	+	16	=	1·87
130	41	+	24	=	1·71	159	44	+	30	=	1·47
142	55	+	30	=	1·83	141	38	+	20	=	1·90
139	40	+	22	=	1·82	111	33	+	21	=	1·57
142	37	+	20	=	1·85	160	51	+	29	=	1·76
147	Average				1·74	141	Average				1·74

Average velocity by chronograph, right barrel, 743 ft.sec.; left, 734 ft.sec.

DICKSON DOUBLE-BARREL PERCUSSION GUN.

Right Barrel. Pattern.	Gauge.		10in. plate.		Force.	Left Barrel. Pattern.	Gauge.		10in. plate.		Force.
110	27	+	20	=	1·35	100	20	+	12	=	1·67
120	33	+	19	=	1·74	130	25	+	14	=	1·79
98	33	+	19	=	1·74	95	29	+	15	=	1·93
86	29	+	17	=	1·71	91	21	+	12	=	1·75
88	14	+	9	=	1·55	82	18	+	10	=	1·80
91	19	+	10	=	1·90	115	29	+	18	=	1·61
99	Average				1·66	102	Average				1·76

Average velocity by chronograph, right barrel, 745 ft.sec.; left, 763 ft.sec.

HARDING SINGLE-BARREL PERCUSSION GUN.

Pattern in 30in. circle.		Force on Gauge.		Pellets on 10in. plate.		Force per pellet.
80	.....	33	+	22	=	1·50
89	.....	29	+	17	=	1·71
110	.....	17	+	10	=	1·70
98	.....	29	+	19	=	1·53
114	.....	40	+	21	=	1·90
90	.....	36	+	20	=	1·80
94	.....	Average	.....			1·69

Average velocity by chronograph, 755 ft.sec.

JOE MANTON DOUBLE-BARREL PERCUSSION GUN.

Right Barrel.							Left Barrel.						
Pattern.	Gauge.	10in. plate.			Force.		Pattern.	Gauge.	10in. plate.			Force.	
119	 35	+	25	=	1·40		128	 30	+	16	=	1·87	
124	 18	+	20	=	0·90		118	 27	+	17	=	1·59	
100	 16	+	20	=	0·80		113	 19	+	14	=	1·36	
103	 35	+	25	=	1·40		98	 17	+	12	=	1·42	
106	 22	+	18	=	1·50		130	 38	+	20	=	1·92	
111	 28	+	18	=	1·56		112	 32	+	17	=	1·88	
110	..... Average	.....			1·26		117	..... Average	.....			1·67	

Average velocity by chronograph, right barrel, 718 ft.sec.; left, 742 f.s. The left barrel balled once.

WESTLEY RICHARDS DOUBLE-BARREL PERCUSSION GUN.

Right Barrel.							Left Barrel.						
Pattern.	Gauge.	10in. plate.			Force.		Pattern.	Gauge.	10in. plate.			Force.	
113	 46	+	28	=	1·64		131	 35	+	21	=	1·67	
116	 22	+	15	=	1·47		118	 28	+	15	=	1·87	
137	 48	+	27	=	1·78		129	 31	+	20	=	1·55	
100	 11	+	9	=	1·22		140	 40	+	23	=	1·74	
130	 30	+	23	=	1·30		111	 20	+	14	=	1·43	
125	 25	+	15	=	1·67		119	 23	+	17	=	1·35	
120	..... Average	.....			1·51		125	..... Average	.....			1·60	

Average velocity by chronograph, right barrel, 755 ft.sec.; left, 715 ft.sec. The left barrel balled once.

BURNETT DOUBLE-BARREL PERCUSSION GUN (Rebored by Charles Lancaster).

Right Barrel.							Left Barrel.						
Pattern.	Gauge.	10in. plate.			Force.		Pattern.	Gauge.	10in. plate.			Force.	
140	 27	+	18	=	1·50		135	 30	+	17	=	1·76	
130	 34	+	21	=	1·62		110	 29	+	18	=	1·61	
141	 31	+	20	=	1·55		143	 38	+	23	=	1·65	
143	 28	+	18	=	1·56		103	 27	+	18	=	1·50	
133	 20	+	18	=	1·67		140	 34	+	20	=	1·70	
120	 25	+	16	=	1·56		138	 32	+	18	=	1·78	
135	..... Average	.....			1·58		128	..... Average	.....			1·66	

Average velocity by chronograph, right barrel, 734 ft.sec.; left, 774 ft.sec.

In order to draw a line of comparison between the guns of the past and those of the present day, we tried the same charge (2drs. of No. 1 powder and 1¼oz. shot) in a 12-bore cylinder gun with 30in. barrels, bored for 3drs. of No. 4 black powder or 42grs. Schultze. The results were as follows:

Pattern in 30in. circle.		Force on Gauge.		Pellets on 10in. plate.		Force per pellet.
141	.....	44	+	31	=	1·42
154	.....	45	+	34	=	1·32
135	.....	27	+	18	=	1·50
136	.....	21	+	12	=	1·75
144	.....	47	+	32	=	1·47
148	.....	38	+	22	=	1·73
143	.....	Average	.....			1·53

The average chronograph velocity of the shots that did not ball with this gun was 628 ft.sec.; but in one instance, where the charge must have balled, the velocity was nearly 200 f.s. higher.

The rapid combustion of the No. 1 powder, when shut up in the breechloading cartridge, does not suit the modern gun. With its customary charge, this breechloader will give a chronograph velocity about 120 ft.sec. higher than here recorded.

The general results of the trial may be summarised as follows:

11-Bores.	Pattern.	Force.	Velocity.
Segalas (flint-lock)	118	1·23	640
C. Lancaster (flint-lock)	144	1·74	739
12-Bores.			
Westley Richards (percussion)	122	1·56	735
Burnett (rebored by C. Lancaster)	131	1·62	754
Modern breechloader (cylinder)	143	1·53	698
16-Bores.			
Mortimer (flint lock)	131	1·68	738
Harding (percussion)	97	1·69	755
20-Bores.			
Dickson (percussion)	101	1·71	754
Joe Manton (percussion)	113	1·47	780

The Time of Ignition with Flint Locks.

We need hardly say that a very noticeable feature in the shooting of the guns with flint-locks was the prolonged time that elapsed between the pull of the trigger and the departure of the shot from the barrel. Wishing to ascertain what proportion this time bears to that which elapses with the modern breechloader, we requested Mr. Griffith, who had previously performed similar experiments with various descriptions of powder in his own breechloader, to undertake a like task with a flint-lock gun. He consented to do so; but, after our own experiences with the most ancient among the representatives of "the flint age"—the Segalas gun—and the discovery of its capacity for misfires, we had not the conscience to trouble him with that relic, so we sent the Mortimer gun, which was free from this defect, and between which and the Lancaster flint-lock there seemed to be no apparent difference.

The results of this trial went to show that there were considerable variations in successive shots—the time from the fall of the hammer (not touch of the trigger) varying from ·0750 sec. to ·1050 sec., with an average of ·0940 sec.; the powder used being No. 1, and the charge the same as in the general trial. With Mr. Griffith's 12-bore breechloader, and the ordinary charge of 3drs. of powder and 1⅛oz. No. 6 shot, the time taken under similar conditions (*i.e.*, from fall of hammer to exit of shot), was, with C. & H. No. 2 T.S. powder, ·0039 sec.; with No. 3 powder, ·0046 sec.; with No. 4, ·0055 sec.; and with No. 6, ·0063 sec. So that, after the trigger of the flint gun was pulled, the shot would be fifteen times as long in getting out of the barrel as when No. 6 powder is fired in a modern breechloader; or seventeen times as long as No. 4 powder; or twenty times as long as No. 3; or twenty-four times as long as No. 2. Mr. Griffith, in sending the results, fervently remarks: "I thank my stars we do not have to work with a flint lock."

The number of instances of "balling" which occurred during the trial of the above-mentioned guns induced us to carry out some experiments with a view to ascertain the cause; and particulars of the result will be found on the next page. P.—T.

(*Field*, April 6, 1889; Vol. 73, p. 465.)

Sir,—May I trouble you with a few remarks *re* "The Guns of our Ancestors." I had in my possession, but sold a month or two ago, a single flint shot gun by Segalas, London, and it in every respect resembled the gun submitted by "20,000 Shots," with the exception of the silver mountings and silver thumb piece, the one I had having steel mountings and thumb piece, with the pointer and the word "Cave," so I should think it must have been a kind of trade mark with Segalas. I think, if you refer, you will find that he was a silversmith and jeweller in the west of London, and that the gun (at least the one I had) was made by Baker in the Whitechapel-road. The gun I had, in addition to the present proof marks (which evidently had been put on recently), also had a private proof mark, such as Baker was allowed to use, with the Prince of Wales's feathers, Baker proving his own guns, and was maker to H.R.H., afterwards King George IV. D. Johnstone.

London Armoury Company, 114, Queen Victoria-street, E.C.

[Having returned the old flint Segalas gun to its owner, we cannot now examine it. Although we did not find the name of Segalas in our search, we noticed that of Baker, of the Whitechapel-road, at the end of the last or early in the present century. We may add, too, that we saw "gunmaker to H.R.H. the Prince of Wales" after the name of John Manton, somewhere about the year 1800.—Ed.]

Sir,—I cannot allow a week to pass without noticing your most interesting and instructive article on the subject of old guns. It will do much, indeed, to dispel the halo of mist—and, I may add, myth—hitherto surrounding their performances; and you will, I am sure, receive the thanks of the whole shooting community for the careful and exhaustive trials you have carried out. Some of the old guns did better, and others worse, than I anticipated; but, on the whole, the results turn out just about what I expected.

Your reference to that man of remarkable discursive genius, Mr. Page, of Norwich, certainly gives us a wonderful instance of loading in putting 2oz. of No. 4 shot into a 19-bore with an equal measure of

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powder. This, after priming from it, would leave a balance of about 4½drs. of powder to go into the barrel, which, considering the fine-grain powder of his day, is, to say the least of it, a pretty good dose. I can well recollect the plan of using a pipe-bowl as a measure, and have used it myself hundreds of times in loading guns borrowed from farmers—the shot being in one bag and powder in another. The common practice was a bowlful of powder, then a lump of crumpled brown paper rammed hard, with two bowlfuls of shot, and again brown paper on the top. The pin was then removed from the touch-hole and the gun primed, the next process frequently being to rub the edge of the flint with a lump of stone brimstone, to insure ignition. It must be remembered, however, that the said pipe bowl was by no means a fixed quantity; there was a vast difference between "a ha'penny pip" and "a churchwarden;" some ha'penny pip's would hold at least ½dr. more than others, but this was not considered a matter of the slightest consequence. In truth it was so with these old fellows, for, slow and poking shots as they for the most part were, they seldom missed; but then it must be borne in mind they would seldom fire at anything much over thirty yards off. Many of their guns, too, had barrels of abnormal length, 3ft. and more; and in many of the old farmhouses would be found in my boy days what they called duck guns—that is, a single barrel 40in. to 50in. long, and of about 18-gauge. Many of these were said to be old Spanish barrels, and wonderful killers of flocks of fowl on the millponds, but I cannot say that I ever found them anything very extraordinary; though, as they were heavily loaded with about No. 1 or 2 shot, it is perhaps no wonder that, if loaded on Mr. Page's principles, kills at great distances would often be made at flocks of ducks swimming on a big pond. The kick was not always to be regarded lightly; and I know, as a boy, I sometimes dreaded pulling the trigger—a cut second finger by the guard, and a bruised cheek, being often the penalty of a shot. After all, a good modern full choke would beat them all to sticks.

ONE WHO HAS FIRED SOME 20,000 TRIAL SHOTS AT MARKS.

Brighton, April 3, 1889.

THE BALLING OF SHOT CHARGES.

(*Field*, April 6, 1889; Vol. 73, p. 464.)

DURING the experiments carried out with ancient guns (of which some particulars are given at page 97) many instances occurred in which the charges of shot balled; and as the balling occurred even more frequently when the old-fashioned charges were used in modern guns, we resolved to carry out some additional experiments with the view of ascertaining the cause of these dangerous results. For the purpose of these experiments, besides the old muzzle-loaders previously mentioned, three breech-loading guns were used—one being a double-barrel gun, both barrels of which were of cylinder boring, and the others were single guns, one being a cylinder and the other a full-choke. The word "cylinder" we use in its conventional sense, as representing a barrel that is not choked.

BALLING IN CYLINDERS—DIFFERENCE OF VELOCITY.

The single cylinder gun was first tried with various charges of powder and shot, and different kinds of wadding, with the intention of making it ball as often as possible. This was attained by using 2drs. of C. & H. No. 1 powder, a felt wad, and 1¼oz. of No. 6 shot (averaging 278 pellets to the ounce). With this charge the single gun balled eight times out of twelve shots fired, several of the charges being thrown in one solid mass like a bullet. The mean velocity in 40 yards of these balled charges, as taken by Messrs. Curtis and Harvey's chronograph, was upwards of 880 feet per second, whereas the average velocity of the unballed charge was barely 700 ft.sec.

The charge of shot was then reduced to 1⅛oz., and afterwards to 1oz., everything else remaining as before. As the weight of shot was lessened, the balling diminished in frequency; and with the 1oz. charge only two instances of balling occurred out of twelve rounds fired.

The next trial was with 2drs. of No. 1 powder, with *two* felt wads on top of powder, and different weights of shot. With 1¼oz., only two charges balled out of twelve; with 1oz. and with 1⅛oz. of shot there was no balling whatever.

With 2drs., 2½drs., or 3drs. of C. & H. No. 4 powder there was no balling, whether 1oz., 1⅛oz., or 1¼oz. of shot was used, or whether with one or two felt wads.

A different batch of No. 6 shot (averaging 266 to the ounce) was then tried. With 1¼oz. of this shot and 2drs. of No. 1 powder, the gun balled much less than with the other sample of the same nominal size; there being only one instance out of twelve shots fired, when a single felt wad was used, and none at all when two felt wads were used between powder and shot.

No. 8 shot was next tried, 1¼oz. being used with 2drs. of No. 1 powder and one felt wad. With this load the gun balled four times out of twelve charges fired; but with the same load, except that two felt wads were placed between powder and shot, no balling occurred.

No. 4 shot was tried under similar circumstances, viz., 2drs. of No. 1 powder, one felt wad, and 1¼oz. of shot. The gun now balled on an average once out of ten charges fired; but on reducing the weight of shot, or using powder of coarser grain, or putting an extra felt wad between powder and shot, the balling ceased.

The double cylinder gun was tried under the same conditions as the single; but, as the results were practically the same, we have not included them in the description.

EFFECT IN CHOKE-BORES.

The choke gun was also tried with all the variations of powder, shot, and wadding, as used in the trial of the cylinder guns; but it never could be made to throw its charge of shot in one compact mass. With 2drs. of No. 1 powder, a single felt wad, and 1¼oz. of No. 6 or No. 8 shot, it would about twice in a dozen shots throw its charge in three or more clusters, accompanied by from thirty to eighty detached pellets; but these clusters disappeared with the additional wad, or powder of coarser grain, or reduction of the shot charge.

To sum up, we may say that the results of the experiments, as far as they go, tend to prove that the balling of shot charges takes place at the breech end of the barrel, and is caused by the sudden blow given when the combustion of the powder is very rapid. On No. 1 powder (the finest grain made) being fired with a heavy charge of shot, the quickness of ignition would cause the greater portion of the powder to be converted into gas before the shot has time to move; and the pressure would consequently be very high, even in the old-fashioned guns. The result was shown in two of the flint guns and two percussion muzzle-loaders balling more or less frequently. But the ill effects were greatly intensified when, as in the breech-loader, the fine-grain powder was placed in close proximity with the cap, and shut up in a cartridge case, the turn-over of which offers far greater resistance to the movement of the shot than would be likely to occur in a muzzle-loading gun, whether flint or percussion. The consequence was that, whereas the old muzzle-loaders balled occasionally under the conditions of loading which were in vogue when they were built, the modern breechloader, when tried under those old-fashioned conditions, balled as a rule rather than as an exception.

EFFECTS OF FINE-GRAIN POWDER AND EXTRA WADS.

In order to ascertain the amount of pressure in the chamber with this fine-grain powder, we requested Messrs. Cogswell and Harrison to test it in their crusher-gauge apparatus; and the record of pressure with 2drs. of No. 1 powder and 1¼oz. of No. 6 shot was found to be about 30 per cent. higher than the ordinary charge of 3drs. of No. 4 powder with 1¼oz. of shot. But this increase of pressure, in all probability, does not fully represent the greatest amount of force exhibited by the charge of fine-grain powder, because, the charge being so small (2drs.), the first plug of the crusher-gauge is too far from the breech to record the pressure until the shot has moved forward; and consequently the strain is lessened before the pressure can be taken.

It will be observed, however, that the tendency to ball is checked by the use of extra felt wadding between powder and shot, as the additional elasticity would of course reduce the suddenness of the blow given by the powder gas. A card wad on either or both sides of the felt wad was tried, but no advantage was shown. A slight variation in the size of the pellets (only twelve pellets in an ounce) also appears to have an important influence on the balling of shot charges when fired from the same gun. According to the size of the pellets, so will they "chamber" more or less compactly in the cartridge case, and, on their being "jumped up" by the blow given by the powder, they may become in some instances wedged together much more tightly than in others where there is a little freer "play" between the pellets.

With regard to the choke gun, the conclusion arrived at was that, although the charge may have been squeezed into a ball at the breech, the mass was broken up on passing through the smaller diameter at the muzzle (which was a full choke). Both hard and soft shot were tried; but with regard to their liability to ball there was nothing to choose between them.

In conclusion, our thanks are due to Messrs. Stephen Grant and Son for the use of their shooting ground at Twickenham (we may add that their butts received severe punishment from the balled charges during these trials); also to Messrs. Curtis and Harvey and Messrs. Cogswell and Harrison for the assistance they respectively rendered in enabling the experiments to be satisfactorily carried out.

P.—T.

REPORTS OF EARLY "FIELD" GUN TRIALS.

THE FIRST TRIAL OF BREECH-LOADERS v. MUZZLE-LOADERS (1858).

THIS TRIAL was the outcome of a long controversy, in which the merits and demerits of the old-fashioned muzzle-loaders and the "new-fangled" breechloaders were discussed very freely, not to say acrimoniously. After the disputation had been going on for many months, there was a change in the Editorship of the *Field*, and in the issue for Jan. 2, 1858, Mr Walsh, the new editor, said: "One of the most interesting of the many discussions on sporting subjects which have lately occupied our columns is that which relates to the advantages and disadvantages of the breechloader. The subject, however, is now worn threadbare, as far as argument is concerned, and nothing but a fair experimental trial, before an impartial judge, is likely to satisfy our readers. . . . On the points of safety and wear-and-tear it is impossible to come to a conclusion by any single trial; but quickness of loading and firing, good shooting, freedom from recoil, fouling, and some other qualities, may fairly be investigated and settled, if the experiments are fairly and impartially conducted. We therefore invite all those interested in the question to a trial of their several guns in some shooting-ground near London."

After some discussion, arrangements were made for a trial of both shot guns and rifles. The former took place at Ashburnham Park, Chelsea, and the latter at the Victoria Rifle Ground at Kilburn, on the 9th and 10th of April, 1858.* The report of both trials was published in the *Field* of April 17, 1858, from which we here make the following quotation from the report written by Mr. Walsh:

THE TRIAL OF SHOT-GUNS.

IT may be in the recollection of most of our readers that, in the month of January last, finding that the discussion on the merits of the breech-loaders *versus* muzzle-loaders was becoming tedious, we determined upon putting the disputed statements of the two parties to a practical test. With this end in view we put a stop to all argument in our columns, believing that a trial in the ordinary way practised by gun-makers was worth a whole cartload of reasoning upon a subject where the data are almost always liable to exception, from depending upon the evidence of the disputant himself. After coming to this conclusion, the next thing was to decide upon the terms of the trial; and here we were met by difficulties on both sides, because it was rather clear that every person who was likely to take a part had already made up his mind upon the question at issue, and was more inclined to support his own opinion than to arrive at the truth. It is true that some bright exceptions might be found; but, taken as a whole, the gun-makers, as well as the gun-users, to whom we applied, were obnoxious to this charge of bias. After this general difficulty, there next came a special one, in reference to the charge of powder to be allowed; for, while the breech-loaders admitted that they required a greater charge in order to bring up their guns to an equality with their rivals, the muzzle-loaders demurred at the allowance, and many of them refused to come into the trial on this ground alone. It appears to our obtuse ideas that, if the increase is admitted to be required, there ought to be no difficulty in conceding it—just as, in the trial of two horses, in order to test their relative value, you put weight on the superior one to such an extent as to bring them together. It must be recollected that this was not a *prize* to be contended for, but a *trial* of the merits of two kinds of gun, in which a superiority in one point, however small, was conceded. All this, however, has been explained in our columns again and again; and we only allude to it here because we were asked the question at the commencement of the trial, and were obliged to avoid its discussion, for the reason that we were met to act, and not to talk, and the terms, being settled, could not be departed from without the assent of all the subscribers.

Beyond this point of difference there was no advantage allowed to either kind of gun, and all belonging to each class were tested alike. We will now consider for a moment what is the requisite tool for the purpose which is required by the sportsman, for whose use alone we proposed the trial.

A gun or fowling-piece is intended for shooting game, such as grouse, partridges, hares, pheasants, rabbits, &c., and is carried by the sportsman, who is generally on foot. Hence it must not be so heavy as to tire his arms in carrying it, and, as a consequence, a limit is set upon the weight, which in our five classes ranged from 7½lb. down to 6½lb.—the lowest point at which a safe gun can be got up, except it is of a very small bore. Next, inasmuch as there can be no doubt that, *cæteris paribus*, a large bore is better than a small one, and a light gun than a heavy one within the above limits, so the two scales are arranged together, the large bore being allowed a greater weight than the small one, which it positively requires for the sake of safety. After these two points, we must decide upon the length of barrel, and here we are again induced to make a compromise between the two extremes, because, though a long barrel (within limits) shoots stronger and further than a short one, yet this is effected at a sacrifice of convenience and weight. For these reasons we fixed the scale of weights and lengths of barrel proportioned to each bore. But, lastly, there is another point of some importance to the sportsman in selecting his guns, and this relates to the amount of recoil which is experienced in shooting them. It is a well known fact that, according to the nature of the boring—that is, to the formation of the tube—will be the degree of recoil experienced; and this will also, in great measure, regulate the strength of penetration. Thus Joe Manton's guns were always celebrated as good killers at long distances; but they were known to "kick" severely, though not to such an extent as to make them discarded by the ardent sportsman. For this reason we determined to test the amount of recoil, *if possible*, though we were told by the gunmakers whom we consulted that the thing was impossible. We did our best, however, and took great pains to construct a machine, which we believe will yet attain our object; though, from a defect in the strength of the spring used, it failed to go high enough at the time of trial, and was obliged to be discarded. Mr Horton, a very ingenious gunmaker at Birmingham, also constructed one on the same principle; but his, like ours, did not go high enough on the first day, though on the second he had altered it to effect our joint purpose. His plan of registering the recoil is more delicate and efficient than that devised by ourselves; but his machine appeared to us more likely to injure the gun, and we have therefore commissioned him to combine the two, which he is now engaged in doing. No one appeared to be at all prepared for the enormous amount of weight which the recoil is equivalent to; and we were told by several practical men that 30lb. or 40lb. would be the outside of the recoil, whereas we find it to reach nearly 100lb., when the guns are loaded with 1¼oz. of shot. Mr Horton's machine was not marked off exactly in pounds; but, on comparing it with Salter's balance, which was that used by us, we believe that some of the guns shot in the trial recoiled to the extent of 120lb. to 130lb., and most of them up to 90lb. or 100lb. Those which registered the above highest weight were wholly useless to the average sportsman, although shooting very strongly; and we were almost ashamed to ask the gentleman who shot those entrusted to us to complete the six discharges, as the recoil was most unpleasant. If this element could have been taken into the calculation, the gun which now heads the third class would have been displaced, for its recoil is so considerable that it would have told against it, so as to counterbalance its other excellent qualities. However, we were fated to be disappointed in our endeavours, and can only look forward to complete our task at a future time. Of one thing we satisfied ourselves—namely, that on the average the breech-loaders exhibited recoiled quite as much as the muzzle-loaders—indeed, the softest we tried belonged to the latter class. Thus we have explained what we wished to test, and how we failed in testing the recoil; and we must now proceed to the trial of the guns as classed in reference to the regularity of shooting, and to the power of penetration at forty, fifty, and sixty yards respectively. Having ascertained by experiment (and this was admitted afterwards at the trial) that a gun would shoot quite as well from our spring rest as from the shoulder, we wished to shoot all in that way, because then the skill of the shooter would not be an element, and all would be on an equality. But here again we found that so much time was consumed in laying the machine, that we were obliged to abandon the plan, and all were shot in the usual way. The targets employed were of an oblong shape, 28in. by 11in. This shape was selected, not as being the best, but as being the most economical; for it was found that, in order to test the large number of guns sent, more than 30*l*. worth of paper would be required, of the full size of thirty inches square. Hence we decided to do what was best under the circumstances, and not the absolute best, though we

* Should anyone wish to examine the correspondence relative to the trials, particulars will be found in Vol. 11 of the *Field*, pp. 4, 28, 51, 72, 92, 115, 155, 175, 215, 256, 275, 276, 298, 321, 325, 347, 362, 390. The full conditions of the trial were given in the first page of advertisements in the *Field* of March 27, 1858.

believe that, with a diameter of twenty-eight inches, the penetration of the shot at the circumference of the rose, as well as the middle, was fully ensured. These targets, made of very stout brown paper, were folded forty times for the shortest distance, thirty for the middle, and twenty for the long length; and it will be seen that few guns penetrated the whole forty papers with any great number of shots. These targets have been carefully examined by our *confrère* Mr Christopher Idle, whose authority will, we are sure, be considered all-sufficient on this matter, and who also took a warm interest in the first day's proceedings, but was obliged to be absent from the second. The powder used was Laurence's No. 2, and the shot No. 5, which was selected as giving rather less trouble in counting the shots than No. 6; but in future we think the latter should be used.

[The guns were divided into five classes—viz.: 12-bores not exceeding 7½lb.; 13-bores, 7¼lb.; 14-bores, 7lb.; 15-bores, 6¾lb.; 16-bores, 6½lb.; but when guns exceeding the specified weights were sent in, they were shot in other classes. Thus a 14-bore of 7½lb. was shot among the 12-bores; but when 12-bores exceeded the limit (and there was one that reached 7¾lb.) they were disqualified.

The trial was at 40, 50, and 60 yards, only one round being fired from each barrel at each distance, with No. 2 powder and No. 5 shot; and, taking into consideration, also, the peculiar form of the targets, the results afford no means of comparison with later trials, and therefore it would be useless to republish the statistical details. As to the immense amount of recoil, it is obvious, from the results of subsequent experiments, that the conclusion stated above was erroneous; but information on this subject will be given further on.—T.]

SECOND TRIAL OF BREECH-LOADERS v. MUZZLE-LOADERS (1859).

(*Field*, 1859; Vol. 13, pp. 297, 505; Vol. 14, pp. 6, 87.)

THE first trial of the old and new type of guns only whetted the appetite for a more thorough investigation of their merits, which took place on the 4th and 5th of July, 1859, at Hornsey Wood House, then a popular pigeon-shooting ground, but now included in one of the "lungs of London," known as Finsbury Park.

There was an entry of twenty-nine guns (fourteen of them muzzle-loaders, and fifteen breech-loaders) as competitors in the trial. Among the old-fashioned guns were four 12-bores, two 13-bores, five 14-bores, two 15-bores, and one 16-bore. They varied in weight from 7lb. 6oz. down to 5lb. 14oz., and averaged 6lb. 11oz. on the whole. But the weight did not diminish gradually with the gauge. There was a 7lb. gun of 14-bore, and another of the same gauge which was the lightest of the whole series, weighing but 5lb. 14oz.; whereas a 15-bore weighed 6lb. 14oz., and a 16-bore was 6¾lb. The breech-loaders were still heavier; two of the 12-bores weighed 7½lb. each; two 16-bores were 7¼lb.; and the lightest of the lot was a 15-bore of 6¼lb. Of this last-mentioned gauge there were four entries, besides three 13-bores and a 14-bore.

The loads then used—nearly forty years ago—will probably seem, to the rising generation of shooters, as strange as the weight of the guns. Of the 12-bore muzzle-loaders three were shot with 2¾drs. of powder and 1¼oz. of shot; another had 2½drs. of powder with 1 5/16oz. of shot. Four guns of 13, 14, or 15-bore used 2¾drs. and 1⅛oz., and one had only 2¼drs. with 1⅛oz.; whereas another had 2¾drs. with 1oz., the largest proportion of powder in the whole series; and two used 2½drs. of powder with 1oz. of shot.

The very small charges of powder, in comparison with the weight of shot, were probably remanents from the olden times when the same measure was used for powder and shot, and equal bulk of both was poured into the barrel. In such event the shot would probably weigh some eight or nine times as much as the powder, the ratio varying more or less with the size of the shot-pellets and the density of the powder-grain.*

The breech-loaders in this trial, however, averaged fully a quarter of a dram more powder than was used in the muzzle-loaders. The average of the former was nearly 3drs., whereas that of the muzzle-loaders was but little over 2⅝drs., though the shot-charges were about the same, averaging nearly 1⅛oz. with both. Indeed, in the course of the previous discussion, it was admitted by the advocates of breech-loaders that these guns, notwithstanding their merits in other respects, had the defect of requiring about a quarter of a dram more powder, in order to give the same penetration as the muzzle-loaders, owing to a loss of power from the explosive force acting indirectly through the paper case instead of directly taking effect on the barrel of the gun.

The patterns, on the whole, were by no means grand. Although the shot-charge averaged 1⅛oz. of No. 6, the average pattern of the muzzle-loaders was only 98 with the right and 116 with the left barrel; and with the breech-loaders it was still less, the average being 92 with

12-BORES.	PATTERN. 40yds. 1st	2nd	60yds. 1st	2nd	PENETRATION. 40yds. 1st	2nd	60yds. 1st	2nd	RECOIL. 1st	2nd
Barrels—										
M.L. (Pape), 6lb. 11oz., 30in., 2¾drs. 1¼oz. [470]	118	158	60	63	33	28	2	5	31·0	34·0
M.L. (Prince), 7lb. 6oz., 30in., 2¾drs. 1¼oz. [418]	98	148	65	52	22	28	2	1	32·5	33·0
M.L.(Pape), 6lb. 8oz., 29½in., 2¾drs. 1¼oz. [387]	116	129	40	46	28	25	1	1	32·0	34·0
B.L.*(Egan), 7lb. 8oz., 30in., 3drs. 1¼oz. [384]	90	144	58	32	30	28	2	0	—	—
B.L.(Prince), 7lb.2oz., 30in., 3drs. 1¼oz. [379]	93	103	62	60	31	24	4	2	—	—
B.L. (Pape), 7lb., 30in., 3drs. 1¼oz. [377]	93	132	38	55	33	26	3	2	34·0	35·0
M.L. (Culling), 6lb. 10oz., 29½in., 2¾drs. 1⅜oz. [342]	103	106	31	35	32	22	0	0	30·5	29·5
B.L. (Hast), 7lb. 8oz., 31in., 3drs. 1¼oz. [287]	77	100	28	32	25	33	0	0	34·5	36·0
B.L. (Reilly), 7lb. 4oz., 30in., 3drs. 1¼oz. [283]	88	91	37	31	27	22	2	1	38·0	36·5
Averages...	97	123	47	45	29	26	2	1	33·2	34·0
13-BORES.										
M.L. (Pape), 7lb., 30in., 2¾drs. 1¼oz. [374]	71	117	61	47	37	29	8	4	—	—
B.L.† (Needham), 6lb. 10oz., 29in., 3drs. 1⅛oz. [354]	65	135	54	24	39	29	1	0	31·0	32·0
M.L. (Egan), 6lb. 14oz., 28in., 2¾drs. 1⅛oz. [351]	113	113	24	46	23	34	0	1	34·0	34·0
B.L.† (Needham), 7lb. 4oz., 28½in., 3drs. 1⅛oz. [298]	95	97	20	31	26	22	0	0	30·5	32·5
B.L. (Elliott), 5lb. 4oz., 28in. 3drs. 1oz. [278]	87	90	28	20	31	20	0	1	34·0	32·0
Averages...	86	110	37	34	31	27	2	1	32·4	32·6
14-BORES.										
M.L. (Culling), 6lb. 11oz., 29½in., 2¼drs. 1⅛oz. [387]	85	147	48	42	19	24	0	0	27·0	26·5
M.L. (Dougall), 5lb. 14oz., 27in., 2¼drs. 1oz. [367]	92	130	60	30	27	25	0	2	31·5	32·5
M.L. (Culling), 6lb., 29in., 2¼drs. 1⅛oz. [361]	101	103	30	55	21	25	0	1	27·0	30·0
M.L.(Reilly), 6lb. 4oz., 29in., 3¾drs. 1⅛oz. [328]	99	99	34	42	32	27	0	8	34·0	37·0
M.L. (Prince), 7lb., 30in., 2¾drs. 1oz. [287]	71	92	52	27	20	29	0	0	34·5	32·0
B.L.† (Francotte), 7lb. 8oz., 29½in., 3drs. 1⅛oz. [218]	48	60	40	31	23	25	0	0	34·0	37·0
Averages...	83	105	44	38	24	26	0	2	31·3	32·5
15-BORES.										
M.L. (O. Smith), 6lb. 14oz., 30in., 2¾drs. 1⅛oz. [401]	101	121	48	55	38	22	3	5	31·5	29·0
B.L.* (Reilly), 6lb. 14oz., 30in., 3drs. 1⅛oz. [353]	105	106	63	26	29	33	6	1	34·5	38·0
B.L.* (Lang), 6lb. 8oz., 29in., 3drs. 1⅛oz. [339]	57	129	52	45	28	20	3	0	30·0	32·0
B.L.* (Prince), 7lb., 30in., 3drs. 1oz. [298]	77	100	41	31	33	26	5	0	35·5	36·5
M.L. (Hast), 6lb. 8oz., 30½in., 2¾drs. 1⅛oz. [262]	55	83	24	44	29	28	0	5	33·5	34·0
B.L.* (Reilly), 6lb. 4oz., 28in., 2¾drs. 1⅛oz [260]	88	101	34	7	18	28	0	0	34·0	36·0
Averages...	80	107	44	35	29	26	3	2	33·2	34·2
16-BORES.										
M.L. (Joe Manton), 6¾lb. 31in., 2¼drs. 1oz. [361]	86	122	57	36	28	27	0	2	31·0	32·0
B.L.* (Reilly), 7lb. 4oz., 30in., 3drs. 1⅛oz. [330]	95	105	50	31	20	27	2	0	—	—
B.L.* (Elliott), 7lb. 4oz., 28in., 2¾drs. 1oz. [310]	73	99	22	42	30	40	0	1	32·0	33·0
Averages...	85	109	43	36	26	31	1	1	31·5	32·5

* The breechloaders marked with the asterisk indicate that they were made on the Lefaucheux principle. Those marked † indicate that they were made from other patents.

* Nowadays (1896) the most commonly used ratio of powder to lead is 1 to 6, as in the case of 3drs. of powder being used with 18drs. (*i.e.*, 1½oz.) of shot; though the proportion of lead is frequently reduced, as in the pigeon-shooting charge of 4drs. to 1⅛oz., where the ratio is 1 to 5. Of course these ratios only apply to black powder.

the right and 96 with the left barrel. One of the muzzle-loaders, with 1⅛oz. of shot, only gave 55 with the right barrel, and 83 with the second; and a breech-loader, with 1¼oz. of shot, gave 48 pellets with the right barrel, and 60 with the left. Some of the guns, however, with the right barrel made considerably larger patterns than with the left. We give a summary of the results, but have departed from the original arrangement, in which the guns were classified by weight, and consequently guns of various gauges were mixed up together. Here, for facility of comparison, they are classified by the size of the bore. The numbers stated in brackets [470] represent the "figures of merit" obtained by the respective guns under the conditions of the trial. In several instances no records were taken of the recoil of the guns.

The following report, written by Mr Walsh, appeared in the *Field* of July 9, 1859:

"It may be remembered that last year (1858) we attempted to measure the recoil of the guns by a machine designed by ourselves, but the spring (Salter's improved balance) only registering 60lb., it was not strong enough for the purpose, and we were obliged to abandon this test. On the present occasion, however, we were enabled to apply it to all but four of the shotguns, and with complete success, its simplicity and accuracy being much approved of by (we believe) all those who witnessed its operation. By examining the table it will be seen that the average recoil of the guns of a 12 and 13-bore was 66½lb., and of 14, 15, and 16-bore, 64½lb., the highest recoil being 76lb., and the lowest 44lb. [In the opposite table, as now arranged, the amount of recoil is one half of that here stated, as explained in page 112.] These results are of great interest, and establish the fact which we always contended for, that the recoil is not in exact proportion to the shooting force of each gun, for, taking the gun which heads the first class, the two barrels penetrated through 28 and 33 sheets respectively at 40 yards, yet the recoil was less than that of the next, by Mr Prince, which pierced 28 and 22 sheets, and still less than the third in that class, which penetrated 25 and 28. The same holds good throughout the series, and we think it may be alleged that, granting the truth of the test, the proportion of recoil to shooting power varies considerably, and that the greatest kicker is not necessarily the strongest shooting gun. Another interesting point here established is, that the Joe Manton gun sent by Colonel Whyte is by no means remarkable for its amount of recoil, the average of its two barrels being 3lb. under that of the average of all the guns tested in its class; and lastly, the breech-loaders are shown to be quite equal in recoil to the average of the muzzle-loaders.

The patterns made by the several guns exhibited were, on the whole, extremely good, and in some cases extraordinarily so. By comparing the two classes, it appears that the average number of shots put into the 30in. circle at 40 yards varies very little. Mr Pape's and Mr Prince's left barrels (in the first of each of their guns) put in the extraordinary number of 158 and 148 shots, or about 50 and 40 per cent. above the average. Mr Ollard's 14-bore (made by Culling, of Downham Market) put in with the left barrel 147 shot, which is a tremendous pattern for a gun of that gauge. His right barrel, however, showed only 85. Mr Culling, the maker, who shot this gun himself, used only 2¼drs. of powder, which will account for the good pattern at 40 yards and the comparative failure in other respects, but more especially for the very slight recoil which this, in common with all his guns, exhibited. At 60 yards the shooting has been extremely good, the pattern being excellent, and the average as compared with last year being decidedly better.

Penetration we hold to be the quality in the shotguns only second to pattern, and we have been at great pains and expense to ascertain the precise power of each. To effect this, each barrel was shot twice at brown paper targets 12in. square, those at 40 yards being composed of 40 thicknesses, and those used at 60 yards of half that number. We employed nearly the same test in 1858, but the surface was more than twice as great, measuring, in fact, 28in. by 11in. It may be remembered that ten guns then pierced the 40 sheets; but, though the paper was somewhat stouter, the shot being No. 5, instead of No. 6 as used this year, the task was not so difficult. On that occasion, as so many shots pierced the whole of the layers, we departed from the usual custom, and registered the number of shots, as we have done on this occasion at 60 yards, but as this year at 40 yards only one gun performed the task, we counted the number of sheets, exactly as is done by Mr Purdey and most of the best makers. The successful gun in this respect *was a breech-loader* of 16-bore (though from its weight shot in Class 1) made by Elliott, of Birmingham; so that it appears that there is no insuperable difficulty in obtaining driving power in this class of guns. Mr Needham's breech-loader also nearly approached to it having driven through 39 sheets with one barrel. Taking, however, the four shots (two at 40 yards and two at 60), Mr Pape's muzzle-loader made the highest score, being in all 78 through the four targets, while Mr Elliott scored 71, and Mr Needham 69 in the same way. The increase in the driving power of the breech-loaders is, however, very considerable as compared with 1858; and there now appears to be little or no difference between the two classes of guns in this important quality.

Having thus gone through the several results, it is now necessary to allude to the comparative merits of the various guns tried on this occasion. The great contest has been as between muzzle-loaders and breech-loaders, and it will be seen that in each class the old-fashioned gun has carried the day, though very closely pressed by its rival. Indeed, so near is the performance of the two, that we cannot think for a moment that for general purposes there can be a doubt of the superiority of the breech-loader, when quickness of loading, safety, and cleanliness are taken into consideration. The present trial has, however, disposed of the claims of the breech-loader to freedom from recoil, credit for which it is shown not to deserve in the slightest degree. That, *with equal charges of powder*, it does not kick so much as the muzzle-loader, is tolerably clear; but with the additional ¼dr. which it requires, it recoils quite as much. The highly creditable performance of Colonel Whyte's Joe Manton is also another feature worthy of being recorded, for though the gun is placed fourth in its class it is considerably above the average in all points but penetration at 60 yards. We have submitted the barrels to several gun-makers familiar with "Joe Mantons," and they all are of opinion that those sent by Colonel Whyte are of his make, while as to their state of preservation there can be no mistake that it is most extraordinary. At present they indicate a recoil below the average, but this may possibly be accounted for by the new breeches put in by Messrs Trulock and Harriss, of Dublin, as stated by Colonel Whyte.

[It is frequently stated that no "cylinder" or "non-choke" guns will give an average pattern of much more than 120, with 1⅛oz. of No. 6 shot at 40 yards; and that, if it exceeds 130, it must be an "improved cylinder," with some amount of "choke" in it. The patterns quoted above, as recorded in 1859, were made about fifteen years before "choke-bores" were talked of; and yet they must have been "improved cylinders," for a 14-bore muzzle-loader gave 147 pattern with 1¼oz. of shot, and another gave 130 with 1oz. (which is equivalent to 146 with 1⅛oz.) in the left barrel; while Colonel Whyte's 16-bore muzzle-loader (made by Joe Manton about half a century before) gave a pattern of 122 with 1oz. of shot, which would be equivalent to 137 with 1⅛oz.) One of the 12-bores made a score of 158 with 1¼oz. the left barrel (which is equivalent to about 142 with the 1⅛oz.); so it would appear that there were "improved cylinders," with some amount of "choke" in them, long before they were designated by that name. And, on consideration, that does not seem very surprising; for there are "recessed chokes" nowadays as well as "ordinary chokes"; and this manner of obtaining closer pattern by varying the thickness of the metal near the muzzle was understood long ago by some gunmakers, as alluded to in an article on "Expansion and Choke," on page 96.—T.]

TRIALS OF PIN-FIRE AND CENTRAL-FIRE GUNS (1866).

(*Field*, 1866; Vol. 27, pp. 189, 429, 449, 451.)

THE third *Field* gun trial, in 1866, was almost entirely confined to breech-loaders, as there was but one muzzle-loader engaged in the contest. The practical purpose of the trial was to ascertain the relative merits of the new central-fire methods of ignition, as compared with the pin-fire cartridges which had been introduced with the French Lefaucheux system. Some of the competing guns were made for use with both kinds of cartridges, and were shot twice over, as in the case of Mr. Henry's patent, which appears as No. 6 in the table below when shot with the central-fire cartridge, and as No. 8 when shot with the pin-fire. The following is a list of the guns and their makers, together with the weight, length of barrels, charge of powder, and size of grain; the charge of shot was 1⅛oz. of No. 6 (280 pellets to the ounce) for the 12-bores; the two 16-bores used 1oz., and the 8-bore 1½oz.

CLASS I.—12-BORES (1⅛OZ. SHOT).

1. Pape, Newcastle (Lefaucheux pin-fire), 7¼lb., 30in.; 3drs. No. 6 grain powder.
2. Pape (Lefaucheux pin-fire), 7lb. 1oz., 30in.; 3drs. No. 6.
3. Greener, Birmingham (his patent pin-fire), 7¼lb., 30in.; 3drs. No. 5.
4. Lancaster, A., London (his patent central-fire), 7lb. 2oz., 30in.; 3¼drs. No. 5.
5. Pape (Lefaucheux pin-fire), 7lb. 1oz., 30in.; 3drs. No. 5.
6. Henry, Edinburgh (his patent, with central-fire cartridge), 6lb. 10oz., 30in.; 3¼drs. No. 6.
7. Pape (his patent central-fire), 6lb. 15oz., 30in.; 3drs. No. 5.
8. Henry (same gun as No. 6, with pin-fire cartridge); 3¼drs. No. 6.

CLASS I.—12-BORES (1¼oz. SHOT)—*continued.*

9. Crane, London (A. Lancaster's central-fire), 7lb. 2oz., 30in.; 3¼drs. No. 5.
10. Henry (his patent central-fire), 7lb. 3oz., 30in.; 3⅜drs. No. 6.
11. A. Lancaster's central-fire, 7lb. 2oz., 30in.; 3¼drs. No. 5.
12. Cogswell and Harrison (their patent central-fire), 6lb. 15oz., 30in.; 3¼drs. No. 3.
13. Berry, Woodbridge (Lefaucheux pin-fire), 7½lb., 30in.; 3¼drs. No. 3.
14. Erskine, Newton Stewart, N.B. (Lefaucheux pin-fire), 7½lb., 30in.; 3drs. No. 3.
15. Cogswell and Harrison (Dougall's pin-fire), 7½lb., 30in.; 3¼drs. No. 3.
16. Thompson, Edinburgh (A. Lancaster's central-fire), 7lb., 30in.; 3¼drs. No. 6.
17. Melland (A. Lancaster's central-fire), 7lb. 1oz., 29in.; 3¼drs. No. 5.
18. Hasdell, London (Lefaucheux pin or central), 7lb., 30in.; 3drs. No. 5.
19. Thompson (Lefaucheux pin-fire), 7lb., 30in.; 3¼drs. No. 6.
20. Elliott, Birmingham (his patent pin-fire), 6lb. 14oz., 30in.; 2¾drs. No. 3.
21. Harlow, Birmingham (his patent pin-fire), 7lb., 30in.; 3¼drs. No. 3.
22. Crane (A. Lancaster's central-fire), 6lb. 13oz.; 3drs. No. 3.
23. Wilson, Horncastle (Lefaucheux pin-fire), 6lb. 13oz., 30in.; 3drs. No. 5.
24. Fletcher, Gloucester (his patent pin-fire), 6lb. 15½oz., 30in.; 3drs. No. 3.
25. Hasdell (Lefaucheux pin or central), 7lb., 30in.; 3drs. No. 5.
26. Cogswell and Harrison (their patent pin-fire), 7lb., 30in., 3¼drs. No. 3.
27. Williamson, Bridgnorth (Lefaucheux pin-fire), 7lb., 30in.; 3¼drs. No. 3.
28. Williamson (muzzle-loader), 7lb. 2oz., 32in.; 3drs. No. 3.
29. Fletcher (his patent pin-fire), 7lb., 30in.; 3drs. No. 3.
30. Hasdell (A. Lancaster's central-fire), 7¼lb., 30in.; 3¼drs. No. 3.
31. Tolley, Birmingham (Lefaucheux pin-fire), 6¾lb., 30in.; 3¼drs. No. 3.
32. Hast, Colchester (A. Lancaster's central-fire), 7lb. 2oz., 30in.; 3½drs. No. 3.

CLASS II.—16-BORES (1oz. SHOT).

1. Pape (Lefaucheux pin-fire), 6lb. 15oz., 29in.; 2½drs. No. 5.
2. Elliott (his patent pin-fire), 5¾lb., 30in.; 2¼drs. No. 3.

CLASS III.—8-BORE (1½oz. SHOT).

1. Elliott (his patent pin-fire), 14¼lb., 36in; 6drs. No. 3.

The following are the results of the trials of thirty-five guns (two being shot both with pin and central-fire cartridges) on May 22 and 23, 1866. All the shots were taken with the foremost foot of the shooter 40 yards from the target, which was a circular plate of iron 30in. in diameter, having a square of paper suspended in the middle of its face, and close to it. This square was composed of forty thicknesses of double imperial brown paper (140lb. per ream), procured from Messrs Pettitt, of Frith-street, Soho, by whom it was cut and tied up at each corner, the size being 10½in. by 9½in.—in round numbers, 10in. square. In counting the pattern, the hits on the iron were added to those on the paper, and in counting the penetration the number of sheets broken by any one pellet were scored. The shot used was Walker, Parker, and Co.'s No. 6, 280 pellets per ounce. Powder—Curtis and Harvey's No. 3, 5, or 6 grain, at the discretion of the shooter, who was allowed any weight he pleased. It is worthy of remark that the eight guns highest on the list used No. 5 or No. 6 grain, and the seven lowest No. 3—a fact telling strongly in favour of coarse powder.

In this trial, for the first time, twelve rounds were fired from each gun, six from the right and six from the left barrel; but in condensing the report, we give only the average pattern and the average penetration made by each barrel, together with the highest round and the lowest round of both. The penetration, as in previous trials, represented the greatest number of sheets pierced by one pellet only; and where an asterisk (*) is placed after numbers in the lowest round, it indicates that the same shot which gave the smallest pattern also gave the least penetration. Similar facts have often been observed in subsequent trials, whether the force of the shot has been recorded by paper pads, or the force-gauge or the chronograph, thus indicating that a wild shot, which scatters the pellets, causes them to lose speed through the greater amount of atmospheric retardation which they undergo.

CLASS I.—12-BORES.		Pattern. Average.	Pattern. Highest.	Pattern. Lowest.	Penetration. Average.	Penetration. Highest.	Penetration. Lowest.	Figure of Merit.
1. Pape, pin-fire, 3drs....	Right	131	146	104	26	31	23	305
" "	Left	123	159	47*	24	27	20*	
2. Pape, pin-fire, 3drs....	Right	134	165	94	24	26	22	299
" "	Left	117	157	52*	24	32	20*	
3. Greener, pin-fire, 3drs.	Right	124	158	110*	24	28	18*	294
	Left	119	137	80	26	30	23	
4. A. Lancaster, central, 3¼drs.	Right	116	141	101	27	30	23	284
	Left	116	150	72*	24	28	21*	
5. Pape, pin-fire, 3drs....	Right	101	153	46	23	27	21	281
" "	Left	133	152	111	23	27	20	
6. Henry, central, 3¼drs.	Right	103	145	40*	23	30	17*	281
" "	Left	127	164	92*	23	27	20*	
7. Pape, central, 3drs....	Right	125	152	93	23	27	20	277
" "	Left	104	141	66*	23	30	15*	
8. Henry, pin-fire, 3¼drs.	Right	112	137	91	21	23	17	271
" "	Left	115	130	101	21	26	20	
9. Crane, central, 3drs.	Right	101	133	99	24	31	21	268
" "	Left	119	144	96	23	32	19	
10. Henry, central, 3¼drs.	Right	118	143	68	25	29	22	261
" "	Left	94	120	64	24	26	23	
11. A. Lancaster, central, 3¼drs.	Right	98	132	74	27	32	21	260
	Left	107	135	87	26	32	20	
12. Cogswell and Harrison, central, 3¼drs.	Right	93	126	37*	23	27	16*	250
	Left	107	126	90	26	30	23	
13. Berry, pin-fire, 3¼drs.	Right	93	104	72	24	27	20	250
" "	Left	107	122	99	25	30	22	
14. Erskine, pin-fire, 3drs.	Right	87	117	61	28	33	24	245
	Left	104	128	84*	25	32	18*	
15. Cogswell and Harrison, pin-fire, 3¼drs.	Right	94	118	59	25	29	18	244
	Left	101	121	59*	24	28	15*	
16. Thompson, central, 3¼drs.	Right	93	120	63	24	28	21	242
	Left	99	129	61	25	33	20	
17. Melland, central, 3¼drs.	Right	96	124	57*	22	29	17*	242
	Left	99	114	79	23	25	22	
18. Hasdell, pin-fire, 3drs.	Right	94	114	65	22	30	19	239
	Left	101	127	81	20	24	16	
19. Thompson, pin-fire, 3¼drs.	Right	107	128	82	23	26	19	232
	Left	78	106	50*	22	29	17*	
20. Elliott, pin-fire, 2¾drs.	Right	80	104	67	24	28	20	231
	Left	102	125	82	24	30	19	
21. Harlow, pin-fire, 3¼drs.	Right	84	110	44*	27	33	24*	230
	Left	93	123	51*	26	30	21*	
22. Crane, central, 3drs.	Right	95	118	63*	23	32	21*	228
" "	Left	86	107	63*	22	32	18*	
23. Wilson, pin-fire 3drs.	Right	84	127	32	21	24	18	225
" "	Left	97	114	61*	22	28	16*	
24. Fletcher, pin-fire, 3drs.	Right	97	110	89	23	27	21	222
	Left	78	92	62*	23	29	18*	
25. Hasdell, central, 3drs.	Right	92	113	68*	22	27	17*	220
" "	Left	83	114	56	23	26	17	
26. Cogswell and Harrison, pin-fire, 3¼drs.	Right	75	114	48	24	30	21	219
	Left	91	111	48	27	33	24	
27. Williamson, pin-fire, 3¼drs.	Right	79	106	41*	24	28	19*	217
	Left	90	106	82	23	28	20	
28. Williamson, muzzle-loader, 3drs.	Right	87	109	55	27	36	22	217
	Left	79*	109	56	22	25	19	
29. Fletcher, pin-fire, 3drs.	Right	85	102	58	24	35	19	210
	Left	75	103	56	25	27	22	
30. Hasdell, central, 3¼drs.	Right	79	106	43	27	31	24	205
	Left	72	84	46*	27	31	23*	
31. Tolley, pin-fire, 3¼drs.	Right	71	87	60	21	32	13	180
	Left	68	92	43	19	29	11	
32. Hast, central, 3½drs.	Right	67	87	43*	20	32	15	164
" "	Left	57	78	34*	19	24	15*	
Mean average of 32 guns ...		98			24			244

CLASS II.—16-BORES.

1. Pape, pin-fire, 2½drs. and 1oz.	Right	100	135	51	21	29	15	264
	Left	118	130	88	24	28	22	
2. Elliott, pin-fire, 2¼drs. and 1oz.	Right	78	93	60	21	23	20	[illegible]
	Left	67	80	50	20	26	18	

CLASS III.—8-BORE.

1. Elliott, pin-fire, 6drs. and 1½oz.	Right	111	143	63	.....			
	Left	105	141	89	.....			

pattern of the
h the left barrel;
rage being 92 with

The "figure of merit" on this occasion was obtained by the simple process of adding together the averages of pattern and penetration with both barrels. Thus, to take the second gun on the list, 134, 117, 24, and 24 make a total of 299; but, as fractions are omitted in reprinting the table, slight variations occasionally occur; for without these fractions the averages of the first gun (131, 123, 26, and 24) make 304 instead of 305. It is thought preferable to retain the original numbers, except as regards fractions, but to mention the cause of the apparent discrepancy.

With regard to the "figures of merit," Mr. Walsh made the following remarks in a leading article when commenting on the results of the trial in the *Field* of June 2, 1866:

"In the three trials of shot guns which we have held, we have gone nearly on the principle of compelling a perfect pattern as the foundation, and super-adding as much penetration as possible. Every disciple of Col. Hawker knows that a gun *must* put about 100 pellets of No. 6 shot into a 30-inch circle at 40 yards, or it will allow birds such as grouse and partridge to escape in the intervals. Thus a groundwork of excellence in one department is established as a *sine quâ non*, and the chief difficulty consists in apportioning the value of penetration to pattern; for every practical gunmaker knows that in grasping at too much of the former he loses a great deal of the latter. The number of hits on the 30-inch circle should represent about one-third of the whole charge of shot, and for that reason it is not so necessary to divide the paper target into a number of sheets corresponding with the average number of pellets in the pattern as at first sight might appear; but it is easily shown, theoretically, that in our present plan the addition of the bare number of sheets penetrated by one pellet to the full number of shot marks on the face of the target may favour 'pattern' at the expense of 'penetration,' in the ratio of difference between the two averages, which are, as will be seen on reference to our table, 98 for pattern and 24 for penetration. It is very remarkable, however, that, practically, the conclusion arrived at by the faulty process differs very little from that which is formed from the calculation founded upon more correct data.

"The skilled arithmetician will at once come to the conclusion that, if the two qualities are tested by the same shots, the totals should be reduced to a common denominator, or the larger may be made to swallow up the smaller. He would therefore lay down the law that the material used for penetration should be composed of such a number of sheets that the average number penetrated should equal the average number of hits, supposing the value of each to be the same. To illustrate this position, let us suppose that A. has a gun which, when tried at the target with the charge best suited to its use in the field, is slightly better than B.'s gun, tried under like circumstances—A.'s making 104 shot marks and penetrating 26 sheets, or a total of 130; and B.'s making 100 and 25 respectively. B., however, says to himself, 'If I use a quarter of a dram less powder, I shall probably fall off 20 per cent. in penetration, but that will only reduce my score by five; whereas I shall doubtless increase the number of shot on the target. If that increase is in the same ratio as the decrease in penetration, I shall improve my score by 15. Thus—

			Total.
Penetration.....	25	loss of 20 per cent. (5).....	20
Pattern.....	100	gain of 20 per cent. (20)	120
	125		140

and if I should only regain 5 per cent. instead of 20 per cent., I should suffer no loss.'

"Some gunmakers would no doubt resort to this expedient; but most of them are aware that the public know the necessity of a good pattern, neither too wide nor too close, and their object in practice is to obtain that result, as was shown in the late trial; and hence no attempt was made to produce a gun capable of throwing all its shot in a mass into the plate, and no harm accrued from the method of calculation we adopted.

"In order, however, to arrive at a proper rule for estimating the 'figure of merit' of the shot-gun, without either increasing the number of sheets of paper shot at for penetration, or diminishing the size of the circle used for the pattern—to both of which there are practical objections—it is only necessary to assume what is shown by our trial, that 100 is about the average pattern made in a 30-inch circle, and 25 the average number of leaves of paper (as used by us) penetrated. Then multiplying the latter by four, the two qualities count on the same footing. Nothing can be gained by pushing loader and ... and it would be in all cases to the advantage of the with one barrel nce what the sportsman requires, the highest com- and two at 60). This plan, therefore, will in future be adopted by being in all 78 thkic or private, which we may carry out."

TRIAL OF CYLINDERS AND CHOKE-BORES (1875).

(*Field*, 1875; Vol. 45, pp. 210, 236, 258, 416, 422, 446, 448, 472, 491. A full report was also published in a pamphlet, now out of print.)

Committee: Colonel Goodlake, A. J. Lane, W. Lort, E. O. Partridge, and L. E. B. Cox, Esqrs.

The four classes of guns entered for this competition were tried at Wimbledon, on the ground of the All England Croquet Club, during the eight days from April 26 to May 4, 1875. It was arranged that Class 2, as being the most important, and containing by far the largest number of entries (78) should be first taken, on Monday, April 26, and two following days; it was open to guns of any kind not larger than 12-bore, so as to permit guns made on old and new principles to compete on equal terms for the 40-guinea cup offered as a prize to the maker of the best weapon. Next followed Class 3, limited to guns of the old type, a £10 cup going to the winner in this contest, for which forty-nine were entered. On Friday evening began the shooting of the large bores in Class 1, which had nineteen entries, and extended over till Monday; and Class 4, for which there were a dozen entries, occupied the remainder of that day. On Tuesday, May 4, the committee carried out a series of experiments with the choke-bores at various ranges. Finally, there was a wear-and-tear trial, extending over six weeks, in order to test the durability of choke-bore guns; winding up with a trial of two kinds of soft shot, for comparison with the results of the chilled shot used throughout the wear-and-tear trial.

In the ensuing pages we report on the various classes in the order in which they were tried. The most material of the conditions under which the guns were entered were as follows:

1. The entries to be confined to gunmakers, and in each class no gunmaker to enter more than three guns. The Editor of the *Field* to be the manager, and his decision on all points to be final, subject only to the committee, who are to be chosen by the proprietors of the *Field*. No entrance fee to be charged for the guns.

4. The guns to be divided into four classes: Class 1, for 8-gauge and under, of any weight or kind of boring, and used with any charge; Class 2, for guns of any kind not exceeding 12-gauge; Class 3, for 12-gauges and under of English boring; Class 4, for 20-gauges and under of any kind of boring. No 12-gauge gun to exceed 7¼lb. in weight, and no 20-gauge to be more than 6lb. The definition of English boring to be, that the fore-end of the bore shall not be enlarged beyond the diameter of its muzzle to the extent of 5-thousandths of an inch at most.

6. The shot to be No. 6, either soft or chilled—about 270 pellets per ounce—to be found by the manager. The charges to be for the 12-bores, 1⅛oz. by weight, and from ¾ to 1oz. for the 20-bores.

7. Every gun to be fired into a pit, five rounds from each barrel, immediately before its trial, with charges similar to those afterwards to be used, and not to be wiped out before the end of the contest.

8. The guns in each class to be tried twice—the first round at 40 yards, with a Pettitt pad of forty-five sheets in the centre of a 30in. circle, six shots each barrel. The greatest number of pellets within the circle to be added to six times the number of sheets penetrated by three pellets, in order to give the figure of merit.

9. For the second round, these six guns are to be shot at a target 4ft. square, having a Pettitt pad in the centre for penetration, and a selected group included in a 30in. circle, to be drawn from a centre fixed on by the competitor or his representative, for pattern. First time, six shots from each barrel, at 40 yards; second time, ditto, ditto, at 60 yards. The figure of merit to be computed in the same way, and the gun making the highest score from both distances combined to be adjudged the winner of the cup or prize.

10. The proprietors of the *Field* bear all the charges of the trial, and will present, in addition, a cup of the absolute value of forty guineas to the winner of Class 2, and £10, or a cup of that value, as may be chosen by the winner of Class 3.

Class 2.—For Guns of 12-gauge and Under, of any Boring, weight not exceeding 7¼lb.; charge of shot, 1⅛oz.; prize, silver cup value forty guineas.

Favoured by magnificent weather, and aided by such a working committee of sportsmen as we have never before met with, backed up also by a thoroughly efficient staff, we have been enabled to carry through the trial of the most important class of guns—namely, those bored on the new principle—exactly in the time which we announced it would probably occupy. Even with all these advantages, it would have been impossible to get through this task if we had not met with the co-operation of the competitors.

We may state that every charge used at the targets was weighed by ourselves, and that every pattern was counted in the presence of the competitors, and under the supervision of one of the committee, who also themselves supervised the pit firing and the target shooting. These gentlemen bestowed unusual pains in taking the score, in which they were aided by two corporals of the Guards acting under

Colonel Goodlake's order, and entirely independent of all trade influences. With these preliminary remarks, we may proceed to the performances of the guns themselves, all of which, in the two principal classes, were of 12-gauge, except one 16-bore entered by Mr. Crane.

We have previously expressed our opinion that the new system of boring is an immense improvement on the old method, if only the wild shots hitherto met with in the recorded trials at Birmingham* and Wimbledon* can be eliminated, and it is found that the guns so bored will stand the test of work. On the first of these points the present trial will satisfy everyone that by longer experience the cause of this want of uniformity has been discovered, or at all events that the effect has ceased; for, by an examination of the returns, it will be seen that the shooting has been unusually regular—far more so than that recorded by us in the trial of 1866. On the present occasion Mr. Greener's lowest pattern with his best gun, out of 24 shots, was 157; Mr. Pape's 89 once, the next being 145 twice; Mr. Baker, out of 48 shots with his two guns, had 78, 105, and 115; while Mr. Davison only dropped to 100, 108, and 115. The same comparative uniformity will be found nearly throughout the long series of trials, indicating such an improvement in this particular as completely to remove the objection which might previously have been urged against the new principle on that score.

The increase of penetration is, as we have before remarked, even more marvellous than the increase of pattern; for it must be remembered that in this trial the number of sheets counted was limited by those broken by 3 shots, and not by a single pellet as before. This makes a difference of about 5 or 6 sheets; for there were a good many guns which thoroughly broke the last sheet of 45 with a single pellet, but none, except one of Mr. Rigby's, pierced 45 sheets with 3 pellets. Of the six left in, Mr. Pape scored 44 × 6 = 240; Mr. Baker getting 39 × 6 = 234; Mr. Greener and Mr. Davison each 38 × 6 = 228. Several pellets at 40 yards broke the sheet-iron facing of the target, $\frac{1}{16}$th inch thick; and the deal frame of the iron plate for defining the 30in. circle was completely reduced to tinder in the two days' shooting, rendering a new one necessary.

With regard to "wear and tear," our present trial only extended to 68 shots with the six winning guns, which each fired 22 cartridges in the first round; then 22 pit shots (after cleaning out); and finally two rounds of 12 each—first at 40 yards and afterwards at 60—the last 46 without being touched with the rod, and leaving no perceptible trace of leading. Three of the competitors left in for the final round (Mr. Greener, Mr. Baker, and Mr. Maleham) agreed, however, to carry on a trial under our supervision, firing with the same gun four hundred rounds a week for six weeks, and taking, after each two hundred, a dozen target shots.†

All the guns left in were used with chilled shot, as were also more than three-fourths of the whole class. The competitors shot in the order of their entry, each in turn shooting one gun until the full list was gone through, when the same process was repeated with those having two or three guns entered.

The following is a list of competitors, the majority of whom entered three guns each. Those who used soft shot are indicated by an asterisk (*).

*Adams and Co., London.
Baker, F. T., London.
Crane, J. H., London.
Crutchloe, J., Oswestry.
Davison, R., Morpeth.
*Dougall, J. D., London and Glasgow.
Gates, F., Derby.
Green, E. C., Cheltenham.
Greener, W. W., Birmingham.
*Holland, J., London.
Higham, C. and H., Liverpool.
*Jackson, R., London.
Jeffries, L., Birmingham.
*Jones, W., Birmingham.
Maleham, C. H., Sheffield.
Murcott, T., London.
Pape, W. R., Newcastle.
Patstone, J., Southampton.
Powell, P., Tonbridge.
*Reilly, Messrs, London.
Richards, W., Liverpool.
Rigby, J. and Co., London and Dublin.
Sumners, W., Liverpool.
Sylven, T., London.
*Tanton, W., Tenterden.
Thomson and Son, Edinburgh.
Tisdall, H. W., Birmingham.
Tolley, J. and W., Birmingham.
*Turner, T., Birmingham.
*Wales, D., Great Yarmouth.
Wilson, E., Horncastle.

Of the seventy-eight guns entered for the principal prize, we give the averages made by the first thirty. These averages represent the mean results of twelve rounds (six from each barrel) fired for pattern and penetration. The penetration is represented by the average number of sheets pierced by three pellets being multiplied by 6; so that, if thirty sheets were pierced, the number registered would be 180.

* We had previously carried out at Birmingham private trials of guns made by Mr. W. W. Greener and Messrs. W. and C. Scott, and we reported thereon in the *Field* of Jan. 30, 1875. We also tried a gun of Mr. Dougall's at Wimbledon, and the results were given in the *Field* of Feb. 20, 1875.

† The report of this wear-and-tear trial will be found at page 109 *et seq.*

Where, in the following table, the letter P is put after the number of the powder, it indicates that it was made by Pigou; in all other cases the powder was made by Curtis and Harvey. In two instances the weight and length of the guns were not recorded in the original report.

	Weight. lb. oz.	Length. inches.	Powder.	Patt. (30in.)	Penet. (× by 6)	Figure of Merit.
Greener	7 4	30	3½drs. No. 4 P	199	206	405
Pape	7 4	30	3¼ „ No. 6	182	200	382
Davison	7 3	30	3 „ No. 6	179	197	376
Baker	7 1	30	3⅛ „ No. 4	175	196	371
Baker	7 4	30	3⅛ „ No. 4	176	188	364
Green	7 0	30	3¼ „ No. 6	172	189	361
Maleham	6 15	30	3 „ No. 6	174	186	360
Green	7 3	30	3¼ „ No. 6	170	188	358
Greener	6 13	30	3¼ „ No. 4 P	161	194	355
Jones	7 0	30	3 „ No. 6	163	191	354
Rigby	6 13	30	3 „ No. 4 P	182	170	352
Davison	7 2	29	3 „ No. 6	166	186	352
Gates	6 10½	28	3 „ No. 6	174	177	351
Maleham	7 2	30	3 „ No. 6	166	183	349
Tisdall	7 3	30	3 „ No. 5	166	183	349
Holland	—	—	3¼ „ No. 6	185	164	349
Green	7 2	30	3 „ No. 6	169	178	347
Jeffries	7 0	30	3¼ „ No. 5	153	192	345
Wales	7 0	30	3 „ No. 6	172	173	345
Thomson	7 3	30	3 „ No. 4 P	171	173	344
Maleham	7 2	30	3 „ No. 6	158	185	343
Tisdall	7 4	30	3 „ No. 5	158	185	343
Thomson	7 3	30	3 „ No. 4 P	166	173	339
Wilson	7 4	30	3 „ No. 4	151	186	337
Crane	7 3	30	3 „ No. 6	168	168	336
Jeffries	7 2	30	3 „ No. 5	146	190	336
Tolley	7 4	30	3 „ No. 6	159	172	331
Holland	—	—	3¼ „ No. 6	168	161	329
Davison	7 3	31	3 „ No. 6	143	185	328
Gates	6 14	29½	3 „ No. 6	149	178	327

CLASS II.—Round 2. (Same charges as before, with selected group of 30in. circle at both distances).

	40 YARDS. Pattern.	Penet.	Figure of Merit.	60 YARDS. Pattern.	Penet.	Figure of Merit.	Final average.
Greener	214	188	402	92	100	192	= 297
Davison	176	191	367	108	97	205	= 286
Pape	173	194	367	91	93	184	= 275
Baker	170	192	362	85	87	172	= 267
Baker	177	190	367	76	85	161	= 264
Davison	174	171	345	84	89	173	= 259

Accordingly, Mr. Greener became the winner of the forty-guinea silver cup.

CLASS III.—FOR 12-GAUGE AND UNDER, of any weight: English* boring; charge of shot, 1⅛oz.; prize, silver cup value 10*l*.

The shooting of the guns in this class commenced on Thursday, and at seven o'clock in the evening the first round was completed, fifteen competitors contesting the prize with thirty guns altogether. The eight highest were selected in order to allow of the chance of two being disqualified on examination of the boring. The following are the averages of the highest fifteen guns:

	Weight. lb. oz.	Length. inches.	Powder.	Patt. (30in.)	Penet. (× by 6)	Figure of Merit.
Davison	7 3	30	3 drs. No. 6	122	170	294
Greener	7 0	30	3¼ „ No. 4 P	126	160	286
Jeffries	7 4	30	3¼ „ No. 5	131	147	278
Maleham	7 0	30	3 „ No. 6	120	157	277
Turner	6 10	30	3 „ No. 6	101	172	273
Davison	7 0	30	3 „ No. 6	125	147	272
Baker	7 2	30	3⅛ „ No. 4	120	151	271
Baker	7 3	30	3⅛ „ No. 4	116	152	268
Reilly	7 0	30	3 „ No. 3	94	171	265
Maleham	7 0	30	3 „ No. 6	111	153	264
Turner	6 12	30	3 „ No. 6	116	148	264
Pape	—	30	3 „ No. 6	118	144	262
Murcott	6 15	30	3 „ No. 6	117	143	260
Turner	7 2	30	3 „ No. 6	100	159	259
Davison	7 4	32	3 „ No. 6	106	153	259

* By English boring we mean that the fore-end of the bore shall not be enlarged beyond the diameter of its muzzle to the extent of 5-thousandths of an inch at most.

CLASS III.—ROUND 2. (Same charges as before, with selected group of 30in. circle at both distances.)

	40 YARDS.				60 YARDS.				
	Pattern.	Penet.	Figure of Merit.		Pattern.	Penet.	Figure of Merit.		Final average.
Turner	148	165	313		58	83	141	=	227
Davison	129	168	297		71	83	154	=	226
Davison	133	163	296		65	72	132	=	216
Jeffries	114	149	263		67	93	160	=	211
Greener	131	154	285		62	73	135	=	210
Malcham..	112	167	279		retired.				

Accordingly, Mr Turner became the winner of the £10 silver cup.

On Friday the eight guns were examined by the manager with a decimal gauge expressly made for the purpose by Mr. Steward, the well-known optician of the Strand. All were either cylindrical or slightly relieved on the old principle, except Mr. Turner's (the ultimate winner), which is enlarged to the extent of 4½-thousandths in the right barrel, and very nearly, but not quite, 5-thousandths in the left. The committee, however, after carefully inspecting the gun, decided in its favour; but Mr. Turner, in the most handsome manner, admitted that it was purposely enlarged to the full limit allowed by the conditions. Not the slightest blame, therefore, attaches to him; but it cannot be denied that this gun is a modified choke-bore. Mr. Turner is anxious, however, that we should state that the cutting out of his winning gun is only about one-fifth or one-sixth of the average cut in the regular "choke-bores," and that it would not interfere with the use of ball, which we think highly probable, from a subsequent examination of the barrels. That a gun so much enlarged behind the muzzle should not have been allowed to compete with those bored on the old system, is now quite clear to us. Still, although Mr. Turner has won the cup strictly within the specified conditions, it cannot be contended that their intention was complied with; and without doubt in our mind Mr. Davison, the second in Class 3, is entitled to be considered as the best on the genuine old plan, since his barrels were not "choked" in the slightest degree. Only one besides Mr. Turner's of the eight guns examined by us was enlarged, and that only 2-thousandths of an inch in one barrel, and 1-thousandth in the other. It appears to us that, with a perfectly clean barrel, the slight "choke" adopted by Mr. Turner had no effect, his average pattern in the first round being only 101·5; but, as the barrels fouled (and from the great heat of the weather the deposit was far beyond the average) the choke became deeper and deeper, and *pari passu* the average pattern increased from 101·5 to 148·5, which was out of all proportion with the usual increase due to the selected group. Mr. Greener's gun improved only from 125·5 to 131·2, while Mr. Jeffries' fell from 131·2 to 113·5, and Mr. Malcham's from 119·7 to 111·6. Both Mr. Davison's guns improved from the same cause on the average to the same extent as Mr. Greener's.

The result of the shooting in this class shows that guns made on the old system have improved since our last trial in 1866, but more in penetration than in pattern. In the 1866 trial the winning pattern was 127·1, which was surpassed in the first round of the present class by Mr. Jeffries, who obtained 131·2. In the second round Mr. Davison made 132·7 and 129 with his two guns, Mr. Greener scoring 131·2, Mr. Turner 148·5 (modified choke); but Mr. Jeffries fell to 113·5. The penetration is undoubtedly improved, and this we fully expected from private trials. In estimating, however, the exact nature of this trial, and comparing its results with those made in private, two things must be taken into consideration: 1st. That in public nerve is always more or less tried, and, however strong it may be, it does not serve the shooter so well as when he is quietly taking aim at home. 2nd. It must be remembered that in public twelve shots are fired, and these twelve only are taken to give the figure of merit; whereas in private we are too apt to select an exceptional series of patterns made in twos or threes, and to consider them as the average of the shooting powers of the gun. Rifle shots know well enough the value of a "fluke;" and the same rule applies still more strongly to shot guns, which are far more "fluky" than rifles.

From the following comparative table of the penetration shown by choke-bores and cylinders, it will be seen that, with equal charges of powder, the choke-bores invariably penetrated more sheets than the cylinder guns; also that an increase of powder was not always attended by increase of penetration. When the powder-charge is excessive, the shot is likely to be scattered; and when the pellets are widely spread, whether owing to the cylinder-bore, or to excess of powder in a choke-bore, they encounter more atmospheric resistance, and accordingly fall off in speed.

CHOKE-BORES.						Penetration.
2½drs. used by	1 gun,	12 rounds, averaged				27·7 sheets.
3drs.	,, ,, 43 guns,	516	,,	,,		28·4 ,,
3½drs.	,, ,, 2 ,,	24	,,	,,		32·0 ,,
3¼drs.	,, ,, 18 ,,	216	,,	,,		29·8 ,,
3½drs.	,, ,, 2 ,,	24	,,	,,		29·9 ,,
CYLINDERS.						
2½drs. used by	1 gun,	12 rounds, averaged				22·5 sheets.
3drs.	,, ,, 20 guns,	240	,,	,,		25·0 ,,
3½drs.	,, ,, 4 ,,	48	,,	,,		23·6 ,,
3¼drs.	,, ,, 4 ,,	48	,,	,,		25·3 ,,

Penetration of choke-bore, with 3drs., 13⅔ per cent. more than cylinder.
,, ,, ,, ,, 3¼drs., 36 ,, ,, ,, ,, ,,
,, ,, ,, ,, 3½drs., 17½ ,, ,, ,, ,, ,,

CLASS I.—For 8-gauge and under, of any weight or kind of boring, and used with any charge.

With regard to the performances of the guns in Class 1, Mr. Greener's 8-bore certainly did wonders at 40 yards, both in pattern and penetration; but beyond this distance the enormous charge of shot (2½oz.) did not seem to be of much service, and it evidently requires a larger size than No. 6 to do justice to these "cannons," which, of course, are only to be treated as duck guns. The "choke" is with them an immense advantage, and this will no doubt be largely used for the above purpose.

The 10-bores disappointed us, as they showed little or no superiority over the 12-bores in any respect—possibly for want of a larger-sized shot; and, as in them the charge both of powder and shot was unlimited, it does not appear that an increase of one-eighth of an ounce in the charge of shot, as strongly desired by Mr. Greener, would have been of much service to him in Class 2.

CLASS I., FOR GUNS OF 8-GAUGE AND UNDER.—ROUND 1 (at 40 yards, with central group in 30in. circle).

	Pattern (30in. circle).		Penetration (× by 6).		Figure of Merit.
GREENER.—8-bore, 15lb., 36in.; 2½oz. chilled; 6drs. C. & H. No. 6	321	.....	189	=	510
TURNER.—8-bore, 10lb. 10oz., 32in.; 2½oz. soft; 5drs. C. & H. No. 6	284	.....	185	=	469
HOLLAND.—8-bore, 12lb. 6oz., 34in.; 2oz. soft; 5drs. C. & H. No. 6	269	.....	140	=	409
GREENER.—10-bore, 9lb. 10oz., 31in.; 1½oz. chilled; 4drs. Pigou No. 4	222	.....	183	=	405
GREENER.—10-bore, 9lb. 9oz., 32in.; 1½oz. chilled; 4drs. Pigou No. 4	213	.....	176	=	389
ADAMS.—10-bore, 8lb. 10oz., 32in.; 1½oz. soft; 3¾drs. C. & H. No. 4	200	.....	181	=	381
GATES.—8-bore, 12lb. 7oz., 33¾in.; 2oz. soft; 5drs. C. & H. No. 6	237	.....	164	=	401
JEFFRIES.—10-bore, 10lb., 32in.; 1½oz. chilled; 3¾drs. C. & H. No. 5	210	.....	181	=	391
REILLY.—8-bore, 14lb. 3oz., 36in.; 1¼oz. chilled; 4drs. C. & H. No. 6	164	.....	198	=	362

CLASS I.—ROUND 2 (at 40 yards and 60 yards, with selected group of 30in. circle at both distances).

	40 YARDS.			60 YARDS.			Final Figure of Merit.
	Pattern.	Penet.	Total.	Pattern.	Penet.	Total.	
GREENER, 8-bore	359	185	= 544	117	74	= 191	367
TURNER, 8-bore	266	199	= 465	102	74	= 176	320
GREENER, 10-bore	241	174	= 415	82	105	= 187	301
ADAMS, 10-bore	221	185	= 406	109	75	= 184	295
HOLLAND, 8-bore	262	134	= 396	85	59	= 144	270

CLASS IV.—FOR GUNS OF 20-GAUGE AND UNDER, of any boring; weight not exceeding 6lb.; charge of shot, ¾oz. to 1oz.

The pretty little 20-bores (of which all actually shot were "choked") beat all the genuine guns in Class III.—both in pattern and penetration, at 40 yards, with the central group figures of merit—by ·3 points, with the exception of Mr. Davison's best gun, which scored 294·4. Thus Mr. Greener's 12-gauge gun, which was the second in the first round of Class III., scored 286, while his 20-bore,

with a similar central group, made 236·3. At the longer range of 60 yards the reduced charges told against the light guns, and they were well beaten by Class III. both for pattern and penetration. We should, however, state that in our opinion all the 20-bores were charged too highly for comfort in shooting, their light weight not absorbing the recoil which the extra pound or 20 ounces in the 12-gauges enables them to do so well, that in Class II., even with 3¼drs. of powder, no unpleasant recoil was complained of either by ourselves or the committee, most of whom fired repeatedly from them at the targets.

Class IV., for Guns of 20-gauge and Under.	40 Yards. Pattern.	40 Yards. Penet.	40 Yards. Total.	60 Yards. Pattern.	60 Yards. Penet.	60 Yards. Total.	Final Figure of Merit.
Greener.—20-bore, 5¼lb., 29in.; 1oz. chilled, 2¼dr. Pigou No. 4	145	141	236	50	54	104	195
Holland.—20-bore, 6lb., 30in.; ¾oz. soft, 2¼dr. C. & H. No. 6	136	129	265	58	59	117	191
Tisdall.—20-bore, 5¼lb., 28in.; 1oz. chilled, 2¼dr. Pigou No. 4	129	126	255	59	64	123	189
Gates.—20-bore, 6lb., 28in.; ¾oz. chilled, 2¼dr. C. & H. No. 3	99	167	266	42	50	92	179
Tisdall.—20-bore, 5¼lb., 28in.; 1oz. chilled, 2¼dr. C. & H. No. 5	129	131	260	44	52	96	178
Malehan.—20-bore, 5¾lb., 28in.; 1oz. chilled, 2¼dr. C. & H. No. 3	106	137	243	52	57	109	176
Reilly.—20 bore, 5lb. 9oz., 28in.; ¾oz. soft, 2¼dr. C. & H. No. 4	71	127	198	Withdrew			—

General Editorial Remarks.

Having now carefully gone through the result of the trials, we have only to describe the nature of the arrangements by which the enormous amount of work recorded in the foregoing tables was got through. In the first place, a butt 18ft. wide by 9ft. 6in. high was constructed of inch boards faced with felt to prevent glancing. In the centre of this horizontally, and with its lower edge 30in. from the ground, an opening 4ft. square was left, to each side of which a wooden door was hinged, so as to fall back from the shooter into the rear of the butt, behind which a waterproof shed was constructed. These 4-foot screens were each in turn faced with a sheet of white paper of the full size for the selected group, but only 30in. wide for the central group, the pads in both cases being suspended from spikes projecting through the paper. To limit the pattern to a 30in. circle in the first round, a strong plate of iron was fixed in the opening in front of the above screens, with a circular hole 30in. in diameter cut out; and in this way the trouble of drawing a circle with a pencil was entirely obviated, as the iron plate made its own definition in every shot; and, what was still more advantageous, it was unerring in its behaviour to all alike. Two markers were stationed behind the butt, one on each side of the opening, and as soon as each shot was made they in turn opened their respective screens or doors; and, while the one closed his screen and the shot was being taken, the other put on a fresh pattern-paper and penetration-pad, each of which had letters and numbers peculiar to its corresponding gun-barrel and round, these on the pattern sheets being 8in. high, and readily visible by all the competitors, even at the 60 yards range. All the cartridge cases (even for the pit, with very rare exceptions) were lettered and numbered in a corresponding manner, so that the committee-man in charge of the firing point could compare each at every single shot, and thus satisfy himself that the targets were properly registered with the guns to which they were subsequently to be scored. As soon as the twelve shots were completed the markers brought them back to the scoring tent on a light truck, when they were as soon as possible counted under the supervision of the committee, either by a member of the *Field* staff or by one of two corporals of the Guards, kindly placed at our disposal by Colonel Goodlake, and in the presence of the competitors. The loading of the pit cartridges was done by members of the committee; but every single trial cartridge from first to last was loaded with its charge of powder and shot, weighed by ourselves in the presence of the competitors, after previously sticking on a thin gummed label, on which its proper letters and numbers were printed, thus—A.L. 1, A.R. 1, A.L. 2, A.R. 2, &c., the corresponding gun being labelled A, B, or C, or, after the alphabet was exhausted, with similar letters crossed with red or blue as required, while L or R indicated the right or left barrel, and the figure showed the particular shot. The plan certainly worked admirably in every respect.

We must now say a few words on the unexpected and total discomfiture of most of the guns that used soft shot at this trial—a result which neither corresponded with our own previously recorded trials of Messrs. Scott's and Mr. Dougall's guns, nor with the private trials made by such experienced hands as Mr. Dougall and Mr. Rigby. Two or three points are here to be taken into consideration, which we throw out for the benefit of our readers. First, the weather was unusually hot and dry, and the fouling was in consequence almost as hard as metal itself, which might affect the soft shot to an extent which had previously not been experienced in the cold north winds which had latterly prevailed. Secondly, the ten pit shots brought this fouling into full operation before the shooting commenced, whereas in all probability the men who regulated the guns began with the barrels clean. Thirdly, the rapid firing necessitated by the number of entries—and rendered much more so than in the usual mode of scoring, by the absence of intervals for that purpose, during which the gun is becoming cool—still further aided the hot weather in producing a hard and rough kind of fouling, which would probably deface the outside pellets of the charge of soft shot to a greater extent than the chilled, and thus reduce both pattern and penetration to a degree quite different from that observed by ourselves and others. Still, it is plain, from the selection of chilled shot by most of those who used Scott's guns at the recent trial, as well as other makers, that Mr. Greener's example had been followed previously to this contest; but the superiority was not supposed to be nearly so great as it was proved to be under the conditions then existing—that is to say, with barrels previously fouled by five pit shots each, and fired at the rate of about one shot per minute under a burning sun and with a dry state of atmosphere. Whether or no the same superiority will be maintained under the ordinary conditions remains to be proved; but that the "choke-bores," on the average, perform better with chilled shot than with soft is tolerably clear, not only from our experience during this trial, but from the united previous experience of a large majority of the competitors in regulating their guns. It has since been asserted that the inferior results obtained from the soft shot was owing to its not being equal to that made by Walker, Parker, and Co. But, as will be found recorded in a subsequent page, a trial was afterwards carried out between the two makes of soft shot, Messrs. Walker and Parker's being supplied for the purpose by Mr. Greener, while the other was part of the stock we had obtained from Messrs. Lane and Neasham for the foregoing trials, and of which we had a sufficient supply left. The result was, that with guns by three different makers, Lane and Neasham's shot proved superior, both in pattern and penetration, to that made by Walker, Parker, and Co., but that neither equalled the chilled shot used from the same guns.

With regard to the wads used, we examined them from time to time, and found them always of the ordinary kind. In most cases a single thin waterproof wad was placed over the powder, then a felt wad, two of which were sometimes used; and usually over the shot a cardboard wad of the ordinary kind, but occasionally a pink-edge medium-sized wad was employed.

It will have been observed that a circle of 30 inches diameter was fired at in the first round, and the guns which came to the front rank in this preliminary contest must necessarily have proved that their barrels had been put together so as to shoot accurately, as well as bored to secure good pattern and penetration. The most successful were afterwards tried at a larger target, from which the competitor selected such group of 30-inches diameter as would give him the best results. The object of this was to eliminate in the final round any element of chance arising from inaccuracy of aim on the part of the shooter. On the whole, however, the variation between the central and selected groups was so trifling that we are confident the latter is not essential to a fair trial; and as it is far more troublesome, we certainly shall never adopt it again.

Lastly, with regard to the figure of merit, we are of opinion that the multiplication of the penetration by six brings out as nearly as may be the desired combination of pattern and penetration, and leaves nothing to be altered in that direction.

It is now generally admitted that there are at least two distinct modes of boring the new guns, well represented by Mr. Greener and Messrs. Scott. The principles on which these two borings are founded were well known to us prior to the trial, and we are now in possession of the exact measurements of these two methods, through the kindness of Mr. Greener and other competitors who had placed their guns at our disposal for that purpose, but with the express condition that we strictly confine the information thus obtained to ourselves. There is, however, no breach of confidence committed

when we state that the only point common to all the modifications we have examined is the existence of a contraction at the muzzle, varying in degree from fifteen-thousandths of an inch (or five-thousandths in Mr. Turner's modified choke-bore gun), to thirty-five thousandths. This contraction is readily seen with the naked eye of an expert, but it requires a gauge of some kind to ascertain its exact extent. As a matter of curiosity, we may mention that we used more than a ton and a half of brown paper in the pads employed for penetration at the recent trials, besides 4½cwt. of white paper (similar to that used for printing the *Field*) for the pattern sheets.

WEAR-AND-TEAR TRIAL OF CHOKE-BORES.

THE following were the conditions for the "wear-and-tear" trial: Each competitor to send in 2500 loaded cartridges altogether, 100 to be taken as samples by ourselves from time to time; all to be charged alike in quantity and weight of powder and shot, the former to be unlimited, and the latter to be 1⅛th oz. chilled; the target charges to be kept separate; wads to be of the ordinary kind. The guns to be under lock and key, and only to be cleaned out at the end of each 200 cartridges fired. Nothing but tow and oil, turpentine, or other vegetable or animal product of a similar character, to be employed in cleaning, and not more than a quarter of an hour to be occupied in that process. Two hundred cartridges to be fired into a pit on the evening of Monday, May 17, commencing at seven o'clock, and 200 on the morning of Tuesday, the 18th, before nine o'clock, with an intervening wipe-out. Then the guns to be cleaned, and twelve target shots taken from each, as in the first rounds of the April trial. The same to be done on Tuesday evening and Wednesday morning in that week, or, if more convenient to all parties, only on the Monday evenings and Tuesday mornings, until 2500 cartridges have been fired, taking the figures of merit at corresponding intervals. We shall examine the state of the barrels with the before-mentioned gauge, and report on them generally from time to time, without, of course, divulging the exact measurements made. The pit shots to be made at the rate of sixty per hour, and in the presence of ourselves, or a person deputed by us.

FIRST WEEK.

On Tuesday evening, May 18 (the commencement of the proceedings having been deferred a day, in consequence of Monday being Bank Holiday), Mr. Greener's representative and Mr. Baker duly put in an appearance at Wimbledon with their guns, prepared to commence the series of trials intended to extend to over 2500 rounds. Mr. Maleham telegraphed to us, asking for a day's delay, which was granted, and his gun was forthcoming on the 20th. On Tuesday Mr. Greener's cartridges were unequally loaded, those for the pit having only 3drs. of powder, while the target cartridges had 3½drs. powder and nearly 1⅛oz. of shot. We were therefore compelled to refuse the latter, and either postpone the trial or allow him the option of using the reduced charge, which alternative he accepted, producing a weaker penetration than he would otherwise have had. As to the guns, Mr. Baker's was one of those which he used in the trial, and had already gone through a severe test; but those of Mr. Greener and Mr. Maleham were got up expressly for the trial, and were quite new. The paper pads used were part of the stock laid in for the recent trials; but, having been exposed to the late hot and dry weather, they had become, we think, more difficult of penetration from that cause. At all events, every gun we have tried against them has done less in this respect than we expected from previous performances. In each case, before the target shots were taken, 200 rounds were fired, the guns being cleaned out with tow and turpentine at the end of each series of 100 shots.

SECOND WEEK.

During the present week Mr. Maleham's gun has been brought up to a level with its competitors, and on the 25th made the extraordinary average pattern of 208.

None of the guns have shown as good penetration in this trial as in the previous one, owing to the fact, which we have only recently discovered, that the pads we now have are made of considerably heavier and stouter paper than that used on April 26 and following days. When the trial was first organised we commissioned Mr. Pettitt to furnish us with 1000 pads of 45 sheets, to be specially made of paper as nearly as possible uniform in its texture, and this order he carried out in a most satisfactory manner. We did not anticipate so large an entry as we had, and consequently were not provided by Mr. Pettitt with much more than the quantity ordered of the specially prepared paper; but we had enough to carry through the 2nd and 3rd classes, leaving at the close of the competition a sufficient number for the "wear-and-tear" trial, made from Mr. Pettitt's ordinary stock, which we now find to be, as before stated, considerably heavier than the specially prepared pads. This must, therefore, be taken into consideration in comparing the two series of trials; but, of course, it will not affect the present one as far as regards its own particular purpose, viz., that of ascertaining the effect of 2500 shots on the guns from which they have been fired, especially as we have in Mr. Baker's gun, which was shot in the first series, a "trial horse" for those of Messrs. Greener and Maleham, which are new.

THIRD WEEK.

All the guns have made higher scores this week than before, except Mr. Maleham's extraordinary average pattern of 208, which is not likely to be repeated; but the increase is to a certain extent due to the strong leading wind which prevailed on Tuesday morning, giving a higher penetration than on the previous days, when the air was almost still. It should be borne in mind that it is scarcely fair to compare Mr. Baker's gun with its present competitors, because it is one of those which competed on April 26; whereas both Mr. Greener and Mr. Maleham have had more than a month's experience to aid them in improving on their previous knowledge, and have both slightly altered the boring of their guns from the plans previously adopted by them, with a view to avoid the consequences of "wear and tear." Mr. Baker's barrels have not worn to any extent appreciable by measurement; but they have evidently been treated without that care which in such a long-continued competition is absolutely necessary, but which was not required for the small number of shots demanded by us in the original contest. The consequence is that the slight amount of rust then acquired prevents the full and proper amount of cleaning which is essential to completely develop the powers of a gun, and which, under the existing conditions of the barrels and our present regulations of cleaning, cannot be obtained. Still, even under these disadvantages, the gun shows no signs of falling off from its first performance at the "wear-and-tear trial;" but it does not display that uniformity of pattern which was previously its remarkable feature—and this, we think, may fairly be attributed to the above cause.

FOURTH AND FIFTH WEEK.

We have now fired these guns upwards of 2000 rounds each, and it is evident that there is no falling off, all of the competitors having made one high score this week, although there was a strong head wind on both days.

SIXTH WEEK.

During the present week we have completed the last days' shooting of these guns. The weather on Monday was as hot as during the first trial, but on Tuesday a little cooler; there was no wind on either day.

The following is a statement of the results obtained with the respective guns in the six consecutive trials:

	Pattern.		Penet.		Figure of Merit.
First Week.					
GREENER (May 19).—12-bore, 30in. laminated steel; 3drs. Pigou No. 4, and 1⅛oz. chilled shot.	190	.....	140	=	330
GREENER (May 20).—Same, except 3½drs. powder	183	.....	159	=	342
BAKER (May 19).—12-bore, 30in. Damascus; 3½drs. C. & H. No. 4, and 1⅛oz. chilled shot.....	126	.....	137	=	263
BAKER (May 20).—Same charge as before.....	127	.....	142	=	269
MALEHAM (May 20).—12-bore, 30in. Damascus; 3½drs. C. & H. No. 6, and 1⅛oz. chilled shot.....	189	.....	132	=	321
Second Week.					
GREENER (May 25).—As before, with 3½drs. powder	174	.....	149	=	323
GREENER (May 26).—As before, with 3½drs.	192	.....	161	=	353
BAKER (May 25).—As before, 3½drs.....	172	.....	142	=	314
BAKER (May 26).—As before, 3½drs.	163	.....	131	=	294
MALEHAM (May 24).—As before, except 3½drs. ...	170	.....	153	=	323
MALEHAM (May 25).—As before, with 3½drs.	208	.....	149	=	357
MALEHAM (May 26).—As before, with 3½drs.	153	.....	140	=	293
Third Week.					
GREENER (June 1).—As before, except 3½drs.	190	.....	175	=	365
GREENER (June 2).—As before, except 3½drs.....	192	.....	163	=	355
BAKER (June 1).—As before, 3½drs.	163	.....	149	=	312
BAKER (June 2).—As before, 3½drs.	181	.....	140	=	321
MALEHAM (June 1).—As before, with 3½drs.	182	.....	151	=	333
MALEHAM (June 2).—As before, with 3½drs.	200	.....	137	=	337
Fourth Week.					
GREENER (June 8).—As before, with 3½drs.....	172	.....	146	=	318
GREENER (June 9).—As before, with 3½drs.....	192	.....	146	=	338
BAKER (June 8).—As before, 3½drs.....	133	.....	136	=	269
BAKER (June 9).—As before, 3½drs.....	177	.....	134	=	311
MALEHAM (June 8).—As before, with 3½drs.	200	.....	133	=	333
MALEHAM (June 9).—As before, with 3½drs.	192	.....	130	=	322

	Pattern.	Penet.	Figure of Merit.
Fifth Week.			
Greener (June 15).—As before, with 3½drs.	176	140	= 316
Greener (June 16).—As before, with 3½drs.	198	153	= 351
Baker (June 15).—As before, 3½drs.	178	143	= 321
Baker (June 16).—As before, 3½drs.	161	138	= 299
Malehan (June 15).—As before, with 3½drs.	174	131	= 305
Malehan (June 16).—As before, with 3½drs.	196	121	= 317
Sixth Week.			
Greener (June 22).—As before, except 3½drs.	168	137	= 305
Greener (June 23).—As before, except 3½drs.	192	150	= 342
Baker (June 22).—As before, 3½drs.	193	131	= 324
Baker (June 23).—As before, 3½drs.	162	129	= 291
Malehan (June 21).—As before, with 3½drs.	148	122	= 270
Malehan (June 23).—As before, with 3½drs.	175	122	= 297

Laminated Steel *v.* Damascus Barrels.

In the above trial it is worthy of remark that two of the guns were furnished with barrels of Damascus iron, and one (Mr. Greener's) with those of laminated steel, and that all stood the test equally well.

General Summary of Results.

The following is a complete return of the figures of merit, pattern, and penetration of the twelve recorded shots taken after each 200 fired into the pit. From this it will be seen that the guns have maintained their shooting powers throughout the trial, extending over six weeks, and on the last Tuesday (June 22) Mr. Baker's figure of merit was higher than on any previous day.

On May 19, 20, 25, and 26, the weather was calm; June 1 and 2, a leading wind; June 8 and 9, a slight head wind; June 15 and 16, a strong head wind; and on June 22 and 23, as stated above, the weather was as hot as in the April trial, with no wind. It will be observed that when there was a leading wind the penetration was generally high, and when there was a head wind it was the reverse.

	Greenne.			Malehan.			Baker.		
May	Patt.	Penet.	Fig. of Merit.	Patt.	Penet.	Fig. of Merit.	Patt.	Penet.	Fig. of Merit.
19	190	140	= 330	189	132	= 321	126	137	= 263
20	183	159	= 342	170	153	= 323	127	142	= 269
25	173	150	= 323	203	149	= 357	172	142	= 314
26	192	161	= 353	153	140	= 293	163	131	= 294
June									
1	190	176	= 365	182	151	= 333	163	149	= 312
2	192	163	= 355	200	137	= 337	181	140	= 321
8	172	146	= 318	200	133	= 333	133	136	= 269
9	192	146	= 338	192	130	= 322	177	134	= 311
15	176	140	= 316	174	131	= 305	178	143	= 321
16	198	153	= 351	196	121	= 317	161	138	= 299
22	168	137	= 305	148	122	= 270	193	131	= 324
23	193	150	= 342	175	122	= 297	162	129	= 291
Aver.	185	151	= 336	182	135	= 317	161	138	= 299

Trial with Soft Shot.

After the conclusion of the wear-and-tear trial the three guns used throughout that contest were tried with soft shot, first with six rounds of Walker, Parker, and Co.'s, and then with a like number of Lane and Neasham's. The shot of the former firm was provided by Mr. W. W. Greener; that of the latter was some of the surplus stock remaining from our April trials. Throughout the wear-and-tear contest chilled shot only was used, and the averages given above will afford a ready means of comparison with the results of the soft shot trial here annexed:

	Walker, Parker, and Co.'s.			Lane and Neasham's.		
Gun.	Pattern.	Penet.	Fig. of Merit.	Pattern.	Penet.	Fig. of Merit.
Greener's	118	115	= 233	136	125	= 261
Baker's	118	124	= 242	178	130	= 308
Malehan's	130	109	= 239	144	113	= 257
Averages	122	116	= 238	153	123	= 276

We have now established beyond doubt that the new principle of boring guns by contracting or "choking" their muzzles is free from the two objections raised against it, namely, first, that the barrels so choked will soon wear away; and, secondly, that they will "lead" so much as to be practically useless. After firing upwards of 2500 shots from each of the three guns to be tested, no falling off of any kind could be discovered, nor did the measurement by callipers vary even to the thousandth part of an inch from the original diameter of the choke.

W.—T.

TRIAL OF EXPLOSIVES AND GUNS (1878).

(*Field*, 1878; Vol. 51, pp. 115, 171, 199, 218, 250, 274, 304, 336, 369, 490, 533, 560, 580, 612, 660. A full report of the trials was also published in a large quarto pamphlet, now out of print.)

Preparatory to the time when we engaged to carry out a trial of explosives, we were occupied in constructing and carefully testing a machine rest for that purpose. Even with the several trials of guns which we have carried through, it has been objected (and with some reason) that a great deal has depended on the skill of the shooter. But in testing explosives this objection would be still more obvious, because they must of necessity be used in the same gun or guns, and either the same person must shoot the guns (which would be almost impracticable in a long series of experiments) or different hands must be employed—to which the competitors might fairly object. Hence it became almost imperative to use a machine rest.

As far as we know, no rest has hitherto been constructed which will give reliable results with either a double-barrelled gun or rifle; for, if rigid enough to suit the single rifle, it causes the double to cross in its line of fire, inasmuch as in all double guns the muzzles are closer together than the breeches. This is done in order to counteract the yielding of the shoulder to the one-sided blow of each barrel. By imitating the human shoulder, however, and allowing a certain amount of elasticity to the slide, we have fortunately succeeded in our efforts; and we have obtained a rest which equals, if it does not improve upon, the best shooting of any of the gunmakers' experts. A gun once fixed in it can be reloaded and fired, without readjustment, for any number of times with both barrels at the same target with satisfactory results; and thus not only is there no delay, but there cannot possibly be ground for any accusation for variation in the skill of the shooter. We exhibited our machine rest in action to the intending competitors and others, on Saturday, March 2, on the same ground at Wimbledon as that where the *Field* gun trial of 1875 took place. Everyone present expressed himself perfectly satisfied, and we therefore decided on using it—the result being that in the final trial we fired nearly 2500 shots from it without a single complaint.

In principle it resembles the rifle rest which we described in the *Field* of April 19, 1862, but it differs in being made of elastic materials, instead of the rigid unyielding slide, which is only fitted for a single barrel. In the new rest a similar parallel hinged slide is used, but it is set in an elastic frame of ash, which we calculated would yield to the same extent as the human shoulder, and experience bears out the theory of this calculation. In the annexed engraving this frame of 2in. ash (*a a a a*) is cut away to show the slide (*b b b*), to the top of which the gun is attached by means of a thumbscrew (*d*), driving a padded clip up against its fore-end; while the barrels are retained in position by two wooden blocks (*c c*), cut out to fit them, but leaving in each an open space above the rib, along which the sight can be taken. A leather breechen is applied to the heel-plate, and tightened by means of a screw-pad (*k*), on the principle of the surgical instrument known as the tourniquet. The ash frame is capable of being adjusted to fit the slide by means of screw bolts, while it is raised and depressed, and moved to either side by the regulating screws (*g h*). Of course a wheel-plate is necessary in the fore-part, to admit of these movements. Above the gun an ordinary steam locomotive gauge (*f*), made by Messrs. Salter, is fixed, which registers the amount of recoil in pounds; and lastly the wedge (*e*) drops down to prevent the shake which would result from the sudden release of the slide.

We now proceed to describe first what we proposed, and secondly what we actually performed, in the long and exhaustive trial of 1878. From our own experience and that of others, we gathered that what the shooting man chiefly wants is to settle the claims of the respective powders to his support, in point of penetrating power of a uniform kind, without excessive recoil, and, within reasonable bounds, with as little recoil as possible. A close pattern, to any extent which may be required, is now proved to be readily obtainable; and hence we did not propose, in testing the action of explosives, to record "pattern" in the same way as when testing the shooting of guns at the last trial; but, taking average penetration as the basis, and looking on variation in result as a defect (differing in degree), we proposed to deduct from the average penetration the difference between the highest and the lowest patterns made in each series. Just before the trial, however, it was suggested that this deduction would be too

great to produce a "positive" figure, and, after giving due notice, we put the matter to the vote, proposing to deduct only the difference between the lowest pattern made and the average pattern, which was at once agreed to. We proposed also to deduct the recoil as measured in pounds by a Salter's balance, and likewise the variation between the highest and lowest recoil in each series. Here again the deduction was found to be too great, and, with the consent of the competitors, we took 50 off the recoil in every case. As finally settled, the figure was made up as follows:

Average penetration of 3 shots, multiplied by 6 as in previous trials, say		180·0
Deduct difference between the lowest pattern made and the average pattern, say	45·3	
Ditto average recoil in pounds above 50	35·5	84·3
Ditto difference between the highest and lowest recoils	3·5	
Figure of merit		95·7

The results of the trial will show the correctness of the principle on which our figure of merit was framed, for both these qualities were thoroughly tested, in the former to the disadvantage of the wood powder, and in the latter greatly to its credit.

The following were the conditions agreed to by the several competitors at Wimbledon on March 2:

1. The trial to take place on the ground of the Wimbledon Croquet and Lawn Tennis Club, commencing on April 29, at ten o'clock, and to be continued daily (weather permitting).

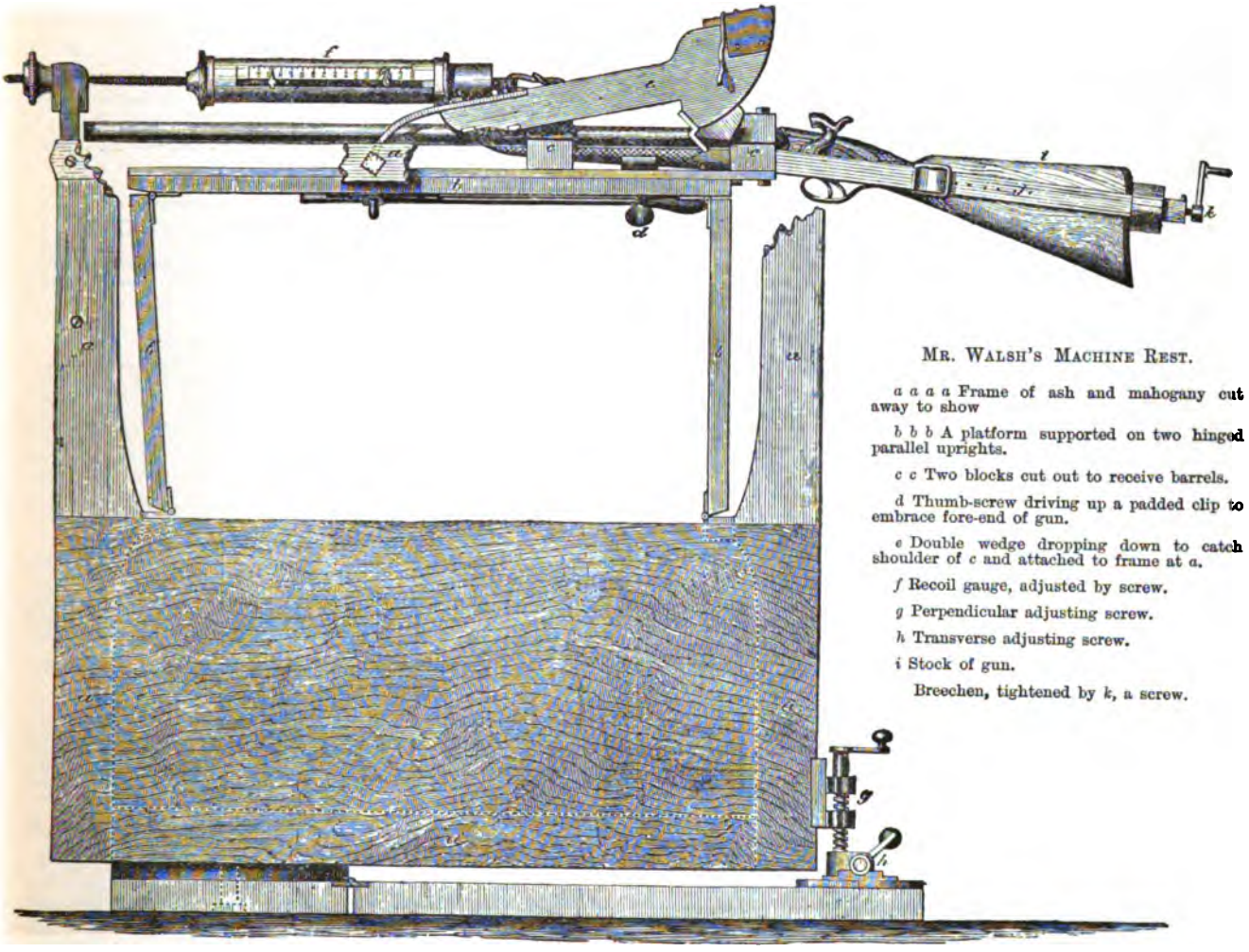
2. The Editor of the *Field* to be manager, and his decision to be final.

3. Every gun to be fired from the machine rest (constructed specially for this purpose by the manager), subject to the supervision of the competitor who enters it, who shall be allowed two trial shots and to examine its "lay" in the machine previous to each shot. Guns to be cleaned out before each trial, or not, at the discretion of the acting competitor.

4. The shots to be all at 40 yards distance from the target, which is of the same kind as that used in 1875, and to be recorded in a similar manner, on white paper within a 30in. circle, in the middle of which is suspended a pad of brown paper of the ordinary dimensions, composed of forty sheets, with a black square of 4in. marked on its centre. The hits on these last are to be recorded, but without coming into the terms of the competition.

5. The figure of merit was estimated according to the calculation previously described.

6. The choke-bored guns to give an average pattern of at least 170, with the powder of their respective enterers, or to be disqualified; and the cylinders one of at least 120. No cylinder gun to have the internal diameter of its barrel larger than that of the muzzle, and the barrel not to be



MR. WALSH'S MACHINE REST.

a a a a Frame of ash and mahogany cut away to show

b b b A platform supported on two hinged parallel uprights.

c c Two blocks cut out to receive barrels.

d Thumb-screw driving up a padded clip to embrace fore-end of gun.

e Double wedge dropping down to catch shoulder of *c* and attached to frame at *a*.

f Recoil gauge, adjusted by screw.

g Perpendicular adjusting screw.

h Transverse adjusting screw.

i Stock of gun.

Breechen, tightened by *k*, a screw.

MR. WALSH'S MACHINE REST.

In introducing our new figure to the readers of the *Field*, we remarked: "The resulting figure of merit will, we think, be a reliable record of the value of the explosive as far as it can be tested by experiment. Manifestly, if wood powder is so variable in its explosive force, as is alleged by some people, and so weak in its penetration, as it is said to be by others, its figure of merit will be a low one; while if the reverse holds good, its virtues will be proclaimed. In any case we shall know something more of its qualities than we now do."

examined for more than 15in. down. Both classes of guns to be central-fire breech-loaders, No. 12 gauge, weight not exceeding 7½lb.

7. The shot to be 1⅛oz. Newcastle chilled No. 6, and to be found and weighed by the manager or his representative.

8. The powder to be found by the several competitors, and to be unlimited; but the weight to be declared to and verified by the manager prior to the shooting.

9. The wads to be of any of the ordinary kinds used in the trade, and to be found by the competitors, and produced prior to the loading, which is to be done by them or their representatives in the presence of their competitors. Any kind of lubrication allowed, so long as it is not such as to be unsuited to the sportsman's purposes, which point is to be decided by the manager if disputed. Eley's green cases to be used, and to be found by the competitors, and also the machine required to turn down the cases, which is to be done to the usual extent. No concentrators to be allowed.

Messrs. Curtis and Harvey, Messrs. Pigou, Wilks, and Laurence, and Messrs. John Hall and Son originally proposed to compete on the side of the old powder; but subsequently Messrs. Curtis and Harvey placed the matter entirely in our hands, agreeing to supply us with any kinds of powder which we might require, and which they accordingly did. To make the trial fair, the Schultze Powder Company were allowed to enter three guns in each class; and, as far as possible, the two kinds of powder were tested alternately throughout the trial, 900 shots (besides two or three trial shots with every gun) being fired by each kind of explosive—that is to say, 900 by the three black powder makers and a similar number by the Schultze Company, each gun being fired twenty-five rounds with the powder of its enterer first, and subsequently the same number by that of its five competitors, in regular order.

In pursuance of the arrangements previously announced in the *Field*, this trial was commenced on Monday morning, April 29, and was continued until Thursday evening, May 9; and we may here remark that, in our long experience of public competitions, we never yet met with such a courteous and chivalrous bearing towards each other by the competitors as has been displayed on this occasion. As we expected, a very interesting contest went on between the Schultze powder and the black, the former in many instances surprising us by its high penetration (three shots several times breaking forty sheets); but, though the patterns given by it were sometimes very high, yet the difference between the lowest shot and the average pattern was so great as to lower the figure of merit below those of its competitors. Instead, however, of giving a high pattern and a low penetration, as had been anticipated, the Schultze powder did exactly the reverse, as will be seen by examining the following tables.

[The records of pattern and penetration originally published gave the shooting of all the rounds fired—twenty-five of each powder with every gun; but they are here condensed into the following summary. In stating the averages, we have given the nearest whole numbers, omitting fractions. Where an asterisk (*) is placed against some of the lowest numbers under the heads of "Pattern" and "Penetration," it serves to indicate that the very same cartridge which gave the lowest pattern, out of twenty-five rounds fired from the same gun, also gave the lowest amount of penetration; and in many other instances where the patterns were poor the penetration was defective likewise, although not actually the lowest of the entire series. It will be found, too, on looking through the records of penetration, that it occasionally happened that not a single sheet of paper was penetrated by three pellets; and yet three pellets formed but a hundredth part of the charge which was fired at the target. The especial object of calling attention to these defective rounds is to make it obvious that when, from irregularity in the strength of the caps or other cause, the charge of shot is so widely scattered as to give a very poor pattern in the 30in. circle, the pellets commonly have but a small amount of penetrative force; for each grain of shot, by becoming fully exposed to the resistance of the atmosphere soon after it leaves the muzzle of the gun, quickly falls off in velocity. On the other hand, if the main body of the shot keeps compactly together after leaving the barrel, and passes through the air for a good distance somewhat in the form of a ball, before spreading greatly, there is comparatively little loss of velocity. Even when only a small portion of the charge "balls," those few pellets retain a much higher amount of speed than the rest of the charge; and similar results are evidenced whether the penetration of the pellets is indicated by means of paper pads, or their force is recorded by the force-gauge, or the velocity ascertained by chronograph, as will be shown hereafter, in reports of subsequent trials. It may here be mentioned, too, that the amount of recoil represented in the following tables is considerably less than was stated in the original report, which gave the full numbers recorded on the scale of the Salter balance. But in these trials the index did not start from zero, as, in order to prevent the "jar" arising from the length of the run, and to procure more steadiness in shooting, the machine was screwed up to 30, as the starting point. Consequently, supposing the movement started at 30, and went up to 100, there would be a recoil through 70 points or pounds on the scale, with a gradually increasing resistance; and dividing the number 70 by 2, in order to ascertain the mean amount of resistance, the result would here be given as 35, instead of 100, as in the original report. In this way the results recorded by Mr. Walsh's apparatus (illustrated on page 111) approximate pretty closely with the foot-pounds recorded by Mr. Phillips's more scientific machine (illustrated on page 123). But the results can only be taken as approximate; as, with the former, the weight of the movable part of the machine was constant—no allowance being made for differences in the weight of the guns; whereas, with Mr. Phillips's apparatus, the weight of the movable portion is regulated in correspondence with the gun's weight, and consequently the "energy of recoil" can be exactly estimated in foot-pounds. Where the guns are all of nearly the same weight, this may not be very material; but with light guns, fired from a heavy machine rest, the record made would be much below the correct proportion.]

The guns which were used in these trials were of the following weights:

	Chokebores (all 30in. barrels).	lb.	oz.
I.	Messrs. Curtis and Harvey's (made by Malehan)	7	2
II.	Messrs. Hall and Son's (made by Malehan)	7	3
III.	Messrs. Pigou, Wilks, & Laurence's (made by W. W. Greener)	7	3
IV.	Schultze Company's No. 1 (made by Malehan)	7	0
V.	" " No. 2 (made by W. W. Greener)	7	3
VI.	" " No. 3 (made by W. W. Greener)	7	3
	Cylinders (all 30in. barrels).		
VII.	Messrs. Curtis and Harvey's (made by F. T. Baker)	7	0
VIII.	Messrs. Hall and Son's (made by F. T. Baker)	7	2
IX.	Messrs. Pigou, Wilks, & Laurence's (made by W. W. Greener)	7	3
X.	Schultze Company's No. 4 (made by Malehan)	7	0
XI.	" " No. 5 (made by W. Powell and Son)	6	15
XII.	" " No. 6 (made by F. T. Baker)	7	0

GUN I.—(Chokebore.)

(1⅛oz. No. 6 shot used throughout.)

Powders.	Pattern. Aver.	High.	Low.	Penetration. Aver.	High.	Low.	Recoil. lb.
C. & H., 3¼drs. No. 6 ...	204	242	152	23	26	18	33·7
Hall, 3¼drs. No. 6 ...	173	227	98	20	26	16	32·5
P. & W., 3¼drs. No. 5	172	224	85	24	30	20	36·3
Schultze, 52 grains ...	195	247	50*	25	31	20*	34·2
" 52 " ...	168	229	84*	25	37	18*	34·0
" 50 " ...	203	253	95	27	36	19	34·0
Averages ...	186			24			34·0

GUN II.—(Chokebore.)

C. & H., 3¼drs. No. 6 ...	197	237	56	24	28	21	33·9
Hall, 3drs. No. 6 ...	179	216	42	22	26	19	32·2
P. & W., 3drs. No. 4 ...	214	249	177	23	28	19	31·4
Schultze, 49½ grains ...	169	255	45	26	34	17	33·4
" 47 " ...	194	244	67*	25	32	0*	33·3
" 42 " ...	167	233	69	28	36	20	33·7
Averages ...	185			25			33·0

GUN III.—(Chokebore).

C. & H., 3¼drs. No. 6 ...	220	235	196	26	31	22	33·4
Hall, 3¼drs. No. 6 ...	188	219	141	26	28	23	34·8
P. & W., 3¼drs. No. 4 ...	211	250	172	24	29	20	33·2
Schultze, 47 grains ...	202	245	100	27	33	21	32·5
" 47 " ...	194	272	135	27	33	22	34·3
" 47 " ...	217	259	151	26	31	23	32·4
Averages ...	205			26			33·5

GUN IV.—(Chokebore.)

C. & H., 3¾drs. No. 6 ...	161	207	99	23	27	17	34·3
Hall, 3¼drs. No. 6 ...	169	208	64*	19	23	13*	33·0
P. & W., 3¼drs. No. 6	147	206	77*	21	26	15*	35·3
Schultze, 52 grains ...	180	235	97	26	33	19	32·5
" 50 " ...	199	252	69	27	32	20	36·7
" 50 " ...	185	240	53*	28	35	15*	34·3
Averages ...	174			24			33·8

GUN V.—(Chokebore.)

C. & H., 3¼drs. No. 6...	212	236	151	24	28	21	33·0
Hall, 3¼drs. No. 6 ...	185	215	135	26	32	20	35·9
P. & W., 3¾drs. No. 4	204	249	120	24	28	20	33·7
Schultze, 47 grains ...	177	244	82*	27	40	21*	33·6
" 47 " ...	188	237	1:0	27	35	24	33·0
" 42 " ...	192	227	106*	27	32	22*	33·4
Averages ...	193			26			33·8

GUN VI.—(Chokebore.)

Powders.	Pattern. Aver.	Pattern. High.	Pattern. Low.	Penetration. Aver.	Penetration. High.	Penetration. Low.	Recoil. lb.
C. & H., 3drs. No. 6	205	242	130	23	28	19	32·2
Hall, 3drs. No. 6	208	237	156*	27	32	21*	34·4
P. & W., 3drs. No. 4... ...	215	242	126*	23	25	18*	32·5
Schultze, 42 grains	211	249	131	25	29	17	31·0
,, 42 ,, ...	166	233	96	27	31	22	31·7
,, 42 ,, ...	180	234	119	26	30	22	32·5
Averages ...	181			25			32·4

GUN VII.—(Cylinder.)

C. & H., 3½drs. No. 4... ...	119	163	58*	23	28	16*	32·4
Hall, 3½drs. Letter A. ...	111	141	53	23	29	18	32·3
P. & W., 3½drs. No. 4 ...	128	181	87*	22	26	17*	30·9
Schultze, 47 grains	103	149	48	23	29	15	30·5
,, 47 ,, ...	103	159	35	24	28	20	31·2
,, 42 ,, ...	102	150	29*	24	33	17*	31·3
Averages ...	111			23			31·4

GUN VIII.—(Cylinder.)

C. & H., 3½drs. No. 4... ...	127	176	43*	23	30	0*	34·2
Hall, 3½drs. Letter A. ...	139	168	113	23	27	16	33·4
P. & W., 3½drs. No. 4 ...	132	161	86	21	26	17	31·8
Schultze, 42 grains	125	150	81	25	31	20	32·7
,, 42 ,, ...	129	166	78	24	33	17	32·1
,, 42 ,, ...	120	171	46*	24	30	16*	32·5
Averages ...	129			23			32·8

GUN IX.—(Cylinder.)

C. & H., 3drs. No. 4	100	143	34*	28	27	14*	32·2
Hall, 3drs. Letter A	110	149	35*	21	26	0*	32·7
P. & W., 3drs. No. 4... ...	111	152	53*	20	26	14*	30·7
Schultze, 42 grains	105	166	47	23	29	12	31·6
,, 40 ,, ...	116	166	48*	23	27	14*	30·9
,, 38 ,, ...	125	167	67*	21	27	17*	28·5
Averages ...	111			22			31·1

GUN X.—(Cylinder.)

C. & H., 3½drs. No. 5... ...	129	163	55	24	29	16	34·3
Hall, 3½drs. Letter A ...	128	170	53	24	29	19	34·9
P. & W., 3½drs. No. 5 ...	126	162	84	23	27	19	34·2
Schultze, 42 grains	122	174	49	22	28	0	32·0
,, 42 ,, ...	135	189	64	25	33	18	32·0
,, 42 ,, ...	138	194	47*	23	31	0*	32·0
Averages ...	130			24			33·2

GUN XI.—(Cylinder.)

C. & H., 3½drs. No. 4... ...	116	149	74*	23	29	16*	33·9
Hall, 3½drs. A mixed ...	116	155	67	23	27	18	35·7
P. & W., 3½drs. No. 4 ...	132	164	69*	21	25	14*	32·8
Schultze, 42 grains	130	158	79	24	28	21	32·1
,, 42 ,, ...	132	178	47	22	26	14	31·7
,, 42 ,, ...	132	183	47*	22	28	0*	31·7
Averages ...	126			23			33·0

GUN XII.—(Cylinder.)

C. & H., 3½drs. No. 4... ...	122	154	37*	22	30	0*	35·7
Hall, 3½drs. A mixed ...	125	155	76	25	30	21	36·5
P. & W., 3½drs. No. 4 ...	123	176	70	24	29	20	36·4
Schultze, 47 grains	135	182	44	24	28	20	32·7
,, 47 ,, ...	135	207	70	23	28	18	32·4
,, 47 ,, ...	125	160	61	22	25	17	31·8
Averages ...	127			23			34·4

In the next series of tables, the results are grouped according to the variety of powder used (heaviest charge first), and the cylinder guns are placed side by side with the chokebores, in order to facilitate comparison.

CHOKE-BORE GUNS.

Curtis and Harvey's Powders.

Gun. Charge.	Pattern.	Penet.	Recoil.
IV.—3¾ drs. No. 6 ...	161	22	34·3
II.—3½ ,, ,, ...	197	24	33·9
III.—3½ ,, ,, ...	204	23	33·7
IV.—3½ ,, ,, ...	220	26	33·4
V.—3½ ,, ,, ...	212	24	33·0
VI.—3 ,, ,, ...	205	23	32·2
Averages ...	200	24	33·4

CYLINDER GUNS.

Curtis and Harvey's Powders.

Gun. Charge.	Pattern.	Penet.	Recoil.
XII.—3½ drs. No. 4	122	22	35·7
X.—3½ ,, No. 5	129	24	34·3
VIII.—3½ ,, No. 4	127	23	34·2
XI.—3½ ,, ,,	116	23	33·9
VII.—3½ ,, ,,	119	23	32·4
IX.—3 ,, ,,	127	23	33·2
Averages... ...	123	23	33·8

CHOKE-BORE GUNS.

Hall and Sons' Powders.

Gun. Charge.	Pattern.	Penet.	Recoil.
V.—3½ drs. No. 6 ...	185	26	35·9
III.—3½ ,, ,, ...	188	26	34·8
IV.—3½ ,, ,, ...	169	19	33·0
I.—3½ ,, ,, ...	173	20	32·5
VI.—3 ,, ,, ...	206	27	34·4
II.—3 ,, ,, ...	179	22	32·2
Averages ...	184	23	33·8

Pigou, Wilks, and Laurence's Powders.

I.—3½ drs. No. 5 ...	172	24	36·3
IV.—3½ ,, No. 6 ...	147	21	35·3
V.—3½ ,, No. 4 ...	204	24	33·7
III.—3½ ,, ,, ...	211	24	33·3
VI.—3 ,, ,, ...	215	23	32·5
II.—3 ,, ,, ...	214	23	31·4
Averages ...	194	23	33·7

Schultze Powder.

I.—52 grains	195	25	34·2
,, 52 ,, ...	168	25	34·0
IV.—52 ,, ...	180	26	32·5
IV.—50 grains	185	28	34·3
,, 50 ,, ...	199	27	33·7
I.—50 ,, ...	203	27	34·0
II.—49½ grains ...	169	26	33·4
,, 47 grains	194	25	33·3
III.—47 ,, ...	194	27	34·3
,, 47 ,, ...	202	27	32·5
,, 47 ,, ...	217	26	32·4
V.—47 ,, ...	177	27	33·6
,, 47 ,, ...	188	27	33·0
II.—42 grains	167	28	33·7
V.—42 ,, ...	192	27	33·4
VI.—42 ,, ...	180	26	32·5
,, 42 ,, ...	166	27	31·7
,, 42 ,, ...	211	25	31·0

CYLINDER GUNS.

Hall and Sons' Powders.

Gun. Charge.	Pattern.	Penet.	Recoil.
X.—3½ drs. A. ...	128	24	34·9
XII.—3½ ,, A. mix.	125	25	36·5
XI.—3½ ,, A. mix.	115	23	35·7
VIII.—3½ ,, A. ...	139	23	33·4
VII.—3½ ,, A. ...	111	23	32·3
IX.—3 ,, A. ...	110	21	32·7
Averages... ...	121	23	34·3

Pigou, Wilks, and Laurence's Powders.

XII.—3½ drs. No. 4	123	24	36·4
X.—3½ ,, No. 5	126	23	34·2
VII.—3½ ,, No. 4	128	22	30·9
XII.—3½ ,, ,,	132	21	32·8
VIII.—3½ ,, ,,	132	21	31·8
IX.—3 ,, ,,	111	20	30·7
Averages... ...	125	22	32·8

Schultze Powder.

XII.—47 grains ...	135	24	32·7
,, 47 ,, ...	135	23	32·4
,, 47 ,, ...	125	22	31·6
VII.—47 ,, ...	103	24	31·2
,, 47 ,, ...	103	23	30·5
VIII.—42 grains ...	125	25	32·7
,, 42 ,, ...	120	24	32·5
,, 42 ,, ...	129	24	32·1
X.—42 ,, ...	135	25	32·0
,, 42 ,, ...	138	23	32·0
,, 42 ,, ...	122	22	32·0
XI.—42 ,, ...	130	24	32·1
,, 42 ,, ...	132	22	31·7
,, 42 ,, ...	132	22	31·7
IX.—42 ,, ...	105	23	31·6
VII.—42 ,, ...	102	24	31·3
XI.—40 grains ...	116	23	30·9
,, 38 ,, ...	125	21	28·5

[Each of the above lines represents the average of 25 rounds, all fired with 1¼oz. of No. 6 shot. It will be observed that the number of sheets penetrated did not necessarily increase with the quantity of powder: the highest average was 28 sheets, and that number was penetrated by 42grs. of Schultze, as well as by 50grs.; while 52grs. did not penetrate more than 26 sheets. The cylinders did not give so much penetration as the choke-bores; but the highest record (25 sheets) was made by 42grs., while 47grs. did not exceed 24 sheets. With both bores, however, the extra powder added considerably to the recoil—more especially with some of the black powders.

The following summary will show the number of sheets penetrated by the respective powders with different charges. With the black powders the choke-bore results were as follows, with 150 rounds of each having been fired, or 25 rounds from each gun:

	Sheets Penetrated.
C. & H. No. 6.—3 drs., average of 25 rounds from 1 gun	23·36
,, ,, 3¼ ,, ,, 100 ,, ,, 4 guns	23·91
,, ,, 3⅜ ,, ,, 25 ,, ,, 1 gun	22·04
P. & W. No. 4.—3 ,, ,, 50 ,, ,, 2 guns	22·76
,, ,, 3¼ ,, ,, 50 ,, ,, 2 guns	23·90
,, No. 5.—3¼ ,, ,, 25 ,, ,, 1 gun	24·20
,, No. 6.—3¼ ,, ,, 25 ,, ,, 1 gun	21·16
Hall's No. 6.—3 ,, ,, 50 ,, ,, 2 guns	24·28
,, ,, 3¼ ,, ,, 100 ,, ,, 4 guns	22·93

Of the wood powder, 450 rounds were fired, and the average results were as follows:

	Sheets Penetrated.
Schultze.—42 grs., average of 125 rounds from 3 guns	26·67
,, 47 ,, ,, 150 ,, ,, 3 guns	26·71
,, 49½ ,, ,, 25 ,, ,, 1 gun	25·60
,, 50 ,, ,, 75 ,, ,, 2 guns	27·39
,, 52 ,, ,, 75 ,, ,, 2 guns	25·28

With Schultze (owing to there being as many rounds fired with the one nitro-compound as with all the black powders conjointly) the same charge was fired several times in succession. Thus, of the 125

rounds with 42 grains, one gun used 75 rounds of this charge, while the other two guns fired but 25 each. Of the 150 rounds of 47grs., one gun used 75, another 50, and another 25; of the 50grs., one gun fired 50 rounds, and another 25; and the same with the charge of 52grs. And it will be observed that with all the powders, both black and nitro, the lowest penetration was given by the largest charge of powder.

With the cylinder guns, which always scattered the shot-charge to a greater extent than the chokebores, there was not the same amount of variation; but a gun made by Baker averaged 24½ sheets penetration with 42grs. of Schultze, and but 23½ sheets when the powder was increased to 47grs.]

Mr. Walsh's Report.

In arranging the conditions of this important trial we were anxious to frame them so as not only to show which is the powder most suitable to the sportsman's breech-loading shot gun, but also at the same time to test the merits of the guns themselves. To a certain extent the powder makers, individually, have been the sufferers; because the gunmakers selected by them have, in some instances, very naturally attended to their own interests first, and, instead of boring their guns so as to shoot best with the special powder of their nominators, have, as far as possible, regulated them so as to shoot with all equally well. In several instances, indeed, guns shot much better with an antagonist powder. But possibly this was a mere question of chance; for the difference between these black powders is so small that we scarcely think it possible for a gunmaker to bore his gun for shooting with one of them so that it would not shoot well with another. Independently of this the powder makers were in the hands of the gunmakers as to load. In several instances (and notably at first with Mr Maleham's guns), pattern—which is of more importance than penetration in getting a good figure of merit—was sacrificed from a desire to get a high average for the latter quality. The experience gained in the first day's shooting taught everyone this; but the mischief was already done, and Mr Maleham suffered accordingly, though, in justice to Mr Greener, we are bound to state that he had previously told us that more than 47 grains of the Schultze powder is too heavy a charge.

In the trial of choke-bores, all the six guns qualified for pattern; but in the cylinders we were compelled to disqualify several, either for being larger in the bore than at the muzzle, or for making an average pattern less than 110. It will thus be gathered that the trial was really one between the choke-bore and the old-fashioned cylinder, as well as a competition between the powder makers; and, being far more exhaustive than that of 1875, is of even higher interest, when regarded from the sportsman's point of view; for although not, like that competition, inaugurating a complete change in the boring of shot guns, it will be found to embrace many particulars which will serve as guides and landmarks for the gunmaker, the powder maker, the cartridge loader, and the sportsman.

To the powder makers we shall address ourselves in their turn; but in the interval we may remark that a change in the wadding alone during the trial improved the regularity of the patterns made by the Schultze powder fully 20 per cent., and probably much more. This change was mainly due to the keen powers of observation possessed by Mr Baker, who had not previously had much experience with the new explosive. He had fully and most honourably complied with our instructions to regulate his two guns with the powders of his respective nominators only; but, finding all his competitors did the best they could "all round," in justice to him we gave our permission to him to follow suit, and the consequence was that, by using hair wads instead of wool, and other trifling manipulations, not only was the average pattern of his own guns wonderfully improved, but Mr Griffith, who loaded the other guns for the Schultze Company, adopted the plan generally, with great success in obtaining regularity of pattern and diminishing the variation in recoil.

From the conditions it will be seen that we had arranged that the several powders were all to be tried out of every gun; and we confess that we made this condition with the expectation that the powder makers would instruct their selected gunmakers to regulate their respective guns for their powders only. It appeared, however, that no such orders had been given by Messrs Pigou and Wilks or by the Schultze Company, or, if given, that they had not been attended to. But in any case there does not appear to have been any drawback to the desirable result which accrued, namely, that with nearly every gun all the powders competed on even terms, each gunmaker seeming to take as much pains with the powders competing against the firm he represented as with that of the latter. This is a very desirable state of things from the sportsman's point of view; but, high as we found the courtesy and chivalrous feeling of the several powder-makers, we certainly were scarcely prepared for such a consummation. In a preliminary article, published in the *Field* of March 9, we stated that "the variation between the several makes" (of the black powder) "is not sufficient to create any great difference of opinion in the sporting world," and that the competition in the main would lie between it and the wood powder. The result of the trial confirms this opinion; for, as will be seen by the following summary, the total variation in the figures made by the black powder is not beyond the range of chance, while the individual scores are still more up and down.

In printing the scores we have not followed the exact order in which the guns were shot, but have, for the purpose of facilitating reference, placed all the black powders together and all the Schultze together. We have also, in the summaries of averages, adopted the alphabetical order, as being more convenient for reference, and insert the fractional parts that are not given in the previous summaries of pattern and penetration.

Final Summary of Figures of Merit.

	With Choke-bored Guns.	With Cylinder Guns.	Total.
Black Powders:			
Curtis and Harvey	29·44	28·81	58·25
John Hall and Son	20·73	41·67	62·40
Pigou, Wilks, and Laurence	28·10	41·59	69·69
Average	26·09	37·36	63·45
Wood Powder:			
Schultze Company, three rounds	8·14	38·74	46·88
	23·14	32·97	56·11
	27·91	21·44	49·35
Average	19·73	31·05	50·78

From this summary it will be observed that Messrs Curtis and Harvey head the list of choke-bores, while they are at the bottom of the cylinders; and in the averages of the two classes of guns they are again at the bottom. Messrs Hall and Son head the cylinders, but are last in the chokes; whilst Messrs Pigou and Wilks can claim to be ahead in the list of total averages composed of chokes and cylinders. Lastly, the win in the cylinder class of Messrs Hall and Son is by a "short head" only, namely, ·08.

Comparing these results with those accruing in the trials of the Schultze powder, in the twelve guns with which it was tested, we find that in some cases the figure of merit has been higher than that of the corresponding black powder, though among the cylinders there are two figures of the latter above the highest of the Schultze powders.

But, notwithstanding this unfavourable result (owing entirely to the occasional wild shot which appears to occur to a greater extent with the Schultze powder than with the black), the company manufacturing it may allege that the penetration made by it is individually superior, as well as on the total average.

With the average patterns we have here no concern, because of necessity they must have been up to the required standard with the guns for which they were regulated; but in the average "difference between the lowest score made and the average pattern" a great falling-off occurs in the Schultze, to which the comparatively low figures are mainly due. Thus the average "difference of pattern" of the choke guns with black powder is 71·59, while that of the corresponding Schultze patterns is 107·66. In the cylinders, the black powder average "difference in pattern" is 58·10, against 68·32 in the Schultze. Lastly, in recoil the Schultze powder showed a decided advantage; but in the average "difference of recoil" its merit was far below that of the black powder, the respective averages being in the chokes, black 5·03, against Schultze 7·25. In the cylinders the respective figures were 3·42 and 6·66.

The comparative performances of the four kinds of powder under the 1878 figure of merit may be made more intelligible to our readers by the following table, which gives them in their arithmetical order, whereas previously we gave them alphabetically:

Table of Results in Arithmetical Order.		Figure of Merit.
Cylinder Guns.	1. John Hall and Son	41·67
	2. Pigou, Wilkes, and Laurence	41·59
	3. Schultze Wood Powder	31·05
	4. Curtis and Harvey	28·81
Choke-bore Guns.	1. Curtis and Harvey	29·44
	2. Pigou, Wilks, and Laurence	28·10
	3. John Hall and Son	20·73
	4. Schultze Wood Powder	19·73
Average in both classes.	1. Pigou, Wilks, and Laurence	34·84
	2. John Hall and Son	31·20
	3. Curtis and Harvey	29·12
	4. Schultze Wood Powder	25·39

Performances of the Several Guns Independently of the Powder Competition.

Having discussed the performances of the twelve competing guns from the powder point of view, and by the figure of merit of 1878, we must now analyse their doings as compared with the trial of 1875, not only individually, but on the average performance with their six different charges.

Early in the competition it was surmised, by Mr Pigou's keen power of calculation, that in order to obtain a high figure of merit it was *as a rule* necessary to keep down the pattern, and indeed to sacrifice the penetration to it, by lowering the charge of powder, which he did in his own case whenever he was able himself to superintend the loading. Of this we were previously fully aware; and it was to guard against the abuse of this condition that we made it a necessary qualification that all the guns in each class should make a specified pattern with the powder of their respective enterers; in other words, that they should not be so bored as to give a uselessly low pattern, which in that case might be made much more uniform than with the moderately high one which the conditions demanded from each gun on its first trial. Obviously, however, this rule does not apply to such carefully-bored guns as that of Mr W. W. Greener, representing Messrs Pigou and Wilks's interests, or to that of Mr Baker, entered by Messrs Hall; for, in the former case, with the enormously high average pattern of 220, the "difference from the lowest" was only 24, while Mr Baker's cylinder, with the high average pattern of 139, gave the "difference" of only 26. On the whole average, however, the "difference" in the cylinders was only about three-fourths of that of the chokes, bearing out Mr Pigou's opinions completely. It was frequently alleged to us that though this condition was a very good one *quoad* the gun, it bore hardly on the powder-makers; but here we must join issue, though we confess that we think the interests of the latter were sometimes sacrificed to those of the former. But there was no hardship, every powder being fairly tried in every gun on similar terms. It very commonly happened that the gun selected for one black-powder maker performed better with the powder of some other firm, the compliment being as frequently returned with the next gun tested. Certainly the black-powder makers have no reason to complain of this part of the conditions, as it bore very severely on their antagonist, the Schultze powder, which would without its institution have occupied a very different position; for, according to our figures of merit of 1875, the following would have been the total averages in the two classes of guns:

Mean Average Figure of Chokebores in 1878, Calculated according to the Conditions of 1875 Trial.

	Penetration.	Pattern.	Figure of Merit.
Schultze Powder Guns	159·06	188·25	347·33
Black Powder Guns	140·00	192·53	332·53
Superiority of Schultze powder over black			14·80

Mean Average Figure of Cylinders in 1878, Calculated according to the Conditions of 1875 Trial.

	Penetration.	Pattern.	Figure of Merit.
Schultze Powder Guns	139·33	122·88	262·21
Black Powder Guns	135·97	121·83	257·80
Superiority of Schultze powder over black			4·41

Doubtless many of our readers will be desirous of knowing how the guns used at this trial of explosives compare with those which competed at the gun trial of 1875. We therefore have selected the final averages of the six choke-bores and six cylinders of the present trial, and have added penetration and pattern together to obtain the figure of merit, in the same manner as was done in 1875. Beneath these figures we have appended the corresponding figures of the last gun trial, so that anyone may see at a glance in what relation they stand to one another.

TABLE OF COMPARISON OF GUNS OF 1878 AND 1875.

Choke-bores.

No. of Table.	Maker.	Pattern.	Penetration.	Figure of Merit.
I.	Malcham	185·93	143·68	329·61
II.	Malcham	186·96	146·68	333·64
III.	Greener	205·29	156·24	362·53
IV.	Malcham	173·56	143·88	327·44
V.	Greener	192·91	155·12	358·03
VI.	Greener	197·71	151·64	359.35
	Average of six guns of 1878	190·39	149·54	339·93
	Average of six highest in 1875	180·75	196·17	376·92

Cylinders.

No. of Table.	Maker.	Pattern.	Penetration.	Figure of Merit.
VII.	Baker	110·05	140·20	250·25
VIII.	Baker	128·57	140·52	269·09
IX.	Greener	110·89	130·16	241·05
X.	Malcham	129·52	140·76	270·28
XI.	Powell	126·51	134·44	260·95
XII.	Baker	127·58	139·84	267·42
	Average of six guns of 1878	122·19	137·65	259·74
	Average of six highest of 1875	120·92	159·21	280·13

In making the above comparison we should draw attention to the fact that in 1875 the six highest guns were selected from upwards of eighty, and though they were no doubt deserving of their position, yet to some extent chance aided their scores; and if they had all six shot again, a considerable alteration would probably have taken place. Secondly, in reference to the apparently reduced penetration displayed in 1878, it must be remembered that the high importance placed by us on regularity of pattern in framing our figure of merit induced the gunmakers during the course of the trial to sacrifice penetration to the former highly desirable quality; and of this there can be no doubt. In addition to which recoil now comes into the calculation; and, from a fear of the consequences in both directions, no gun was shot with 3½drs. of powder, with a view to obtain high penetration, as was the case in 1875. Lastly, the Schultze powder now comes into play, though a careful analysis of the tables will show that it has operated advantageously; for, while the whole average pattern of 1878 is a trifle higher than that of 1875, the penetration of 1878 would have been still more reduced than it has been but for the Schultze powder, which gave a considerably higher average penetration than the black powder. It may probably be asserted that the paper supplied by Messrs Pettitt in 1878 was stouter or tougher than that of 1875; but there is an important fact which tells against this excuse for the deficiency of penetration recently displayed—namely, that the cylinder penetration of 1878 is, as nearly as may be, similar to that of 1875. With a view to set at rest this important point, we have, by a curious chance, been enabled to test the gun shot by Mr John Rigby in the trial of 1875, which was the only one that penetrated the 45 sheets with three pellets, and which gave an average penetration of 170. This gun has been little used, and has been kept in the most perfect condition by one of the customers of Mr. Rigby, who is of opinion that its barrels are in exactly the same condition as in 1875. On testing this gun in our machine rest on May 13, with similar pads to those used at our late trial, the average penetration was about 144, whereas its average penetration in 1875 was 170—tending to prove that the pads of 1878 are really stouter than those of 1875. There is one other possible explanation of the above curiously conflicting results—namely, that the high temperature and dry condition of the air during the whole of the 1875 trial were in favour of the chokebore, as compared with the cylinder at that trial, and also with the choke at the trial recently completed.

More than one missfire in a thousand is regarded by sportsmen as an abomination (by the way, there were but two in the whole 2500 shots, one with the black powder, and the other with the Schultze); but a missfire is far better than a pattern of 50 or 60 at forty yards, because in the latter case "fur or feather" will seldom be killed, and may probably be wounded without being bagged—a consummation to be carefully avoided, on the score of cruelty and bad economy. Now such patterns occurred, as a rule, in nearly all the scores made in 1875, even in the small series of twelve shots then adopted. Mr. Greener's winning gun varied from 235 to 146 in the first round, and from 237 to 191 in the second; while among the scores of the five guns shot against it in Class 2 the following figures appear—namely, 133, 89, 78, 115, and 100. So that if the "figures of merit" on that occasion were calculated on the principle of that of 1878, the subtraction of the "difference between the lowest pattern and the average," in addition to the properly estimated deduction for recoil, would, with some of them, make a very poor "figure" indeed. It was from a due consideration of this weak point in modern guns that we ventured to alter the conditions for the "figure of merit."

Test of the Centre of the Pattern.

It will be observed, in No. 4 of the conditions of the trial, that there was to be a black square of 4in. marked in the centre of the brown paper pad, and the hits thereon were to be recorded, but without coming into the terms of the competition. The reason for doing this was in order to carry out the suggestion made by a correspondent, to "mark off in the centre of the 30in. circle a square of 4in., and ascertain how many pellets would be put in; it would show what chance a partridge would have." Every pad was accordingly furnished with a 4in. paper square fixed in its middle, on which

the number of pellet marks was registered and entered in our books. It would be useless to print these to the extent of the whole series of 1800 shots, but we will give the numbers made by the five highest in each class at 40 yards, and also the number of pellet marks made by these guns afterwards tested by us at 50 and 60 yards.

Commencing with Greener's gun, which gave the high average pattern of 220 with C. & H. powder, 211 with P. & W. powder, and 188 with Hall's powder, the number of pellets in the 4in. square, or sixteen square inches, in the twenty-five rounds (twelve from the right, and thirteen from the left barrel) were respectively as follows, at the 40 yards distance. And it will be seen that with two powders, an average of about ten pellets were placed within the sixteen square inches, and with the third powder two pellets less:

CHOKEBORE GUN, No. III.—At 40 yards.

Powder.	Right Barrel.	Average.
C. & H.	10, 12, 7, 7, 10, 11, 8, 12, 10, 6, 10, 16	= 10
Hall	5, 4, 5, 8, 4, 14, 11, 6, 8, 7, 3, 8	= 7
P. & W.	9, 21, 8, 10, 7, 7, 11, 7, 5, 7, 12, 7	= 9
	Left Barrel.	
C. & H.	6, 12, 12, 10, 14, 9, 10, 10, 9, 11, 6, 7, 9	= 10
Hall	8, 8, 11, 9, 7, 14, 5, 9, 4, 8, 9, 8, 13	= 9
P. & W.	9, 9, 10, 12, 13, 9, 9, 11, 7, 8, 10, 13, 16	= 10

We also give the records of two other choke-bores—one being Greener's second Schultze gun, which gave an average pattern of 208 with Hall's powder; and the other was Maleham's gun, made for Messrs. Hall, which gave an average of 214 with P. & W. powder:

CHOKEBORE GUN, No. V.—At 40 yards.

Powder.	Average.
Hall.—Right barrel	10, 4, 9, 8, 5, 11, 8, 8, 6, 8, 8, 5 = 7
Hall.—Left barrel	14, 7, 6, 8, 9, 8, 16, 12, 7, 8, 8, 14, 4 = 9

CHOKEBORE GUN No. II.—At 40 yards (Pattern, P. & W., 214).

Powder.	Average.
P. & W.—Right barrel	4, 6, 11, 7, 16, 7, 5, 12, 4, 9, 10, 8 = 8
P. & W.—Left barrel	13, 6, 8, 7, 6, 13, 9, 7, 7, 8, 13, 7, 6 = 8

CYLINDER GUN, No. VIII.—At 40 yards (Pattern H., 139; S., 129).

Powder.	Right Barrel.	Average.
Hall	6, 6, 2, 3, 5, 4, 5, 1, 6, 5, 2, 4	= 4
Schultze	2, 3, 3, 2, 4, 4, 1, 2, 4, 2, 9, 5	= 3
Schultze	1, 10, 2, 0, 1, 2, 1, 3, 5, 3, 6, 5	= 3
	Left Barrel.	
Hall	5, 11, 6, 3, 4, 5, 5, 5, 5, 3, 7, 1, 8	= 5
Schultze	4, 1, 2, 4, 8, 1, 5, 6, 6, 3, 9, 4, 4	= 4
Schultze	2, 2, 5, 7, 8, 6, 6, 5, 2, 3, 4, 7, 5	= 5

CYLINDER GUN No. XII.—At 40 yards (Pattern S., 125).

Powder.	Average.
Schultze.—Right barrel	2, 4, 3, 2, 6, 11, 5, 5, 4, 3, 4, 1 = 4
Schultze.—Left barrel	3, 2, 0, 0, 4, 3, 1, 2, 7, 2, 2, 5, 2 = 3

CYLINDER GUN No. XI.—At 40 yards (Pattern C. and H., 116).

Powder.	Average.
C. & H.—Right barrel	3, 0, 1, 8, 2, 4, 4, 4, 3, 0, 2, 5 = 3
C. & H.—Left barrel	3, 6, 5, 4, 0, 5, 3, 7, 2, 9, 0, 6, 6 = 4

50 YARDS.

MR. GREENER'S WINNING CHOKE, with No. 6 shot.

Powder.	Right Barrel.	Average.
P. & W.	4, 4, 5, 6, 5, 6, 5, 7, 5, 5, 7, 6	= 5
C. and H.	5, 4, 3, 5, 6, 3, 4, 5, 2, 2, 6, 5	= 4
Schultze	5, 4, 4, 2, 6, 4, 3, 2, 4, 3, 2, 4	= 4
	Left Barrel.	
P. & W.	8, 4, 5, 6, 4, 6, 5, 4, 5, 3, 5, 5, 5	= 5
C. & H.	6, 3, 3, 4, 4, 5, 5, 6, 4, 3, 3, 4, 3	= 4
Schultze	6, 3, 4, 4, 6, 5, 5, 2, 5, 4, 5, 3, 4	= 4

Ditto, with No. 5 shot.

	Right Barrel.	
Schultze	5, 4, 6, 4, 5, 1, 5, 6, 6, 3, 3, 5	= 4
P. & W.	3, 4, 2, 4, 4, 4, 4, 3, 5, 4, 2, 5	= 4
	Left Barrel.	
Schultze	2, 3, 5, 7, 3, 4, 6, 4, 3, 4, 3, 3, 3	= 4
P. & W.	3, 4, 5, 2, 5, 2, 3, 4, 3, 3, 5, 4, 4	= 4

MR. BAKER'S MODIFIED CHOKE, with No. 6 shot.

Powder.	Average.
C. & H.—Right barrel	4, 3, 6, 3, 2, 4, 4, 3, 3, 4, 3, 5 = 4
C. & H.—Left barrel	3, 3, 3, 3, 4, 4, 4, 4, 4, 5, 3, 4, 2 = 4

MR. BAKER'S CYLINDER No. VIII.

Powder.	Right Barrel.	Average.
Hall's A.	4, 2, 3, 3, 2, 3, 2, 3, 3, 1, 2, 2	= 2
Schultze	4, 3, 5, 3, 2, 4, 4, 3, 3, 4, 3, 5	= 4
	Left Barrel.	
Hall's A.	2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 3, 2, 3	= 2
Schultze	1, 3, 2, 2, 5, 3, 3, 2, 3, 4, 2, 4, 3	= 3

MR. POWELL'S CYLINDER.—At 50 yards, with No. 6 shot.

Powder.	Right Barrel.	Average.
P. & W.	1, 2, 2, 3, 2, 1, 0, 2, 3, 1, 2, 2	= 2
Schultze	1, 2, 2, 1, 4, 0, 0, 2, 3, 4, 0, 2	= 2
	Left Barrel.	
P. & W.	2, 3, 1, 1, 2, 2, 2, 1, 2, 2, 2, 2, 2	= 2
Schultze	2, 2, 0, 5, 2, 1, 5, 1, 2, 4, 2, 0, 2	= 2

MR. GREENER'S CHOKE.—At 60 yards, with 1⅛oz. No. 6 shot.

Powder.	Average.
P. & W.—Right barrel	3, 1, 3, 4, 3, 2, 3, 4, 5, 2, 1, 3 = 3
P. & W.—Left barrel	3, 2, 2, 3, 3, 2, 3, 2, 3, 2, 2, 3, 2 = 2

Same Gun, with 1¼oz. No. 5.

Powder.	Right Barrel.	Average.
P. & W.	3, 3, 2, 1, 3, 1, 2, 4, 2, 3, 5, 3	= 3
Schultze	3, 2, 3, 2, 6, 3, 0, 4, 3, 2, 2, 3	= 3
	Left Barrel.	
P. & W.	2, 2, 3, 3, 3, 2, 3, 1, 2, 3, 3, 3	= 2
Schultze	1, 2, 3, 3, 4, 4, 4, 2, 2, 3, 3, 2, 4	= 3

TRIAL OF PATTERN AT 50 YARDS AND 60 YARDS.

	With 1⅛oz. No. 6. at 50 yards.			Same at 60 yards.		
GREENER'S CHOKE:	Aver.	Hgst.	Lwst.	Aver.	Hgst.	Lwst.
C. & H., 3¼drs. No. 4	132	160	100	—	—	—
P. & W., 3¼drs. No. 4	154	182	122	89	117	62
Schultze, 45grs.	129	184	64	111	144	42
BAKER'S MEDIUM CHOKE:						
C. & H., 3¼drs. No. 4	115	144	67	—	—	—
POWELL'S CYLINDER.						
P. & W., 3¼drs. No. 4	67	96	18	—	—	—
Schultze, 42grs.	76	139	18	—	—	—
BAKER'S CYLINDER:						
Hall, 3¼drs. A.	77	94	56	—	—	—
Schultze, 45grs.	95	128	48	—	—	—
GREENER'S CHOKE:	With 1⅛oz. No. 5 at 50 yards.			Same at 60 yards.		
P. & W., 3¼drs.	120	142	95	89	108	52
Schultze, 45grs.	127	153	74 (42grs)	95	130	61

[The penetration was also taken, but we do not reprint the results, as they were misleading, owing to the paper pads not being of equal thickness, it having been supposed that a portion of the pad might be dispensed with at the longer ranges. Some guns and powders were tried at pads of 20 sheets, others at 25 sheets, and others at 40 sheets; and no comparison can be drawn between them. For instance, a gun was fired at pads of 20 sheets, and in every round but one all the sheets were penetrated. The same gun and charge were afterwards tried at 25 sheets, and four-fifths of the rounds penetrated every sheet. Another powder was then tried at similar pads, and the first nine rounds penetrated all the sheets; whereupon the pads were increased to 40 sheets, and then the number penetrated diminished considerably—varying from 16 to 25 sheets, and barely reaching 22 on the average. It is obvious, therefore, that the springiness of the paper varies with the thickness of the pad, and thus modifies the amount of penetration.—T.]

TRIAL OF POWDER NEARLY A CENTURY OLD.

On Thursday, May 9, 1878, we tried Mr. Baker's modified chokebore with some finely grained powder made by an ancestor of Mr. Pigou in 1790, which has been lying in a brick vault ever since, but which produced most wonderful shooting at 40 yards, both in pattern and penetration. The tin-plate of the case was entirely corroded, so that a very slight touch of the finger and thumb burst the walls, which were previously broken, allowing the powder to escape; but nevertheless it seemed as strong as ever, and, as above remarked, produced most excellent targets. These were commenced by ourselves; but, in consequence of other engagements, they were chiefly conducted by Mr. Lane ("Twenty Thousand Shots"), whose assistance throughout the trials was of the highest value. The results we leave him to record as follows:

MY DEAR SIR,—I send you a copy of my notes on the 1790 powder. The pattern would certainly have been much higher could we have got a greater

elevation—the top of the circle being very thin—and most likely another sheet or two of penetration, as the central shots were always really below the pad. This powder was of very fine grain, an excellent colour, very hard, and perfectly clean. It was shot with Mr Baker's modified choke, hard shot No. 6, 30in. circle at 40 yards.

Patterns very good and even, but all low, the gun rest not permitting a greater elevation; and probably 3dr. and 1⅛oz. would have done still better. This powder has certainly kept most marvellously. A. G. L.

[The following is a summary of the results, in which the recoil is stated in the same proportion as in previous parts of the 1878 report.]

	Pattern.		Penetration.		
	Right.	Left.	Right.	Left.	Recoil.
2¾drs., 1⅛oz. ...	... 160	170	24	25	30·7
,, ,, ...	... 209	148	24	21	30·7
,, ,, ...	... —	219	—	24	30·7
3¼drs., 1⅛oz. ...	... 145	162	27	30	34·0
3¼drs., 1¼oz. ...	... —	163	—	26	34·0

W.—T.

TRIAL OF 12, 16, AND 20-BORE GUNS (1879).

(*Field*, 1879; Vol. 53, pp. 161, 521, 523, 535.)

Committee: Capt. Mayo, Messrs. A. J. Lane, and W. T. Mainprise.

When we were asked to test the powers of 20 and 16-bores against the standard 12, we undertook the task without the slightest idea that either one or the other could hold its own, and all that we contemplated was the arrival at the exact handicap between them. We believed that in the hands of a weak man, unable to carry weight, a 20-bore would do better at game than a 12; but that a strong man could perform as well with the "popgun" as with the 12-bore we never dreamed. Once more, however, we are shown that nothing but actual experience is to be relied on in gunnery; for in the present trial the 12-bores barely hold their own at 40 yards, taking for granted that our figure of merit is conducted on sound principles, which we fully believe it to be. It is alleged that the 30in circle just suits the small bores; but then it also suits the sportsman, and has long been the accepted target for testing his guns. Manifestly, if a larger area is to be covered, 300 pellets will cover it better than 250; but, as we said before, the sportsman is contented with a 30in. plate, and, that being the case, the matter is now set at rest; and clearly no allowance should be made at the pigeon trap for the small bore, if the weight of the gun is not to be taken into consideration.

We have the satisfaction of being able to state that both the competitors and spectators are perfectly satisfied with our "force gauge," which, by the aid of Mr Green, of Cheltenham, and Mr Jones, of Birmingham, we have now made a very perfect machine. One chief merit in our eyes is that it registers the *average* force of the middle of the charge, and not that of three pellets only, which was done by the old brown-paper pad. This latter test, we fancy, misled the gunmaker into the use of too much powder, which would drive a limited number of exceptionally hard pellets with great force, while the bulk are deformed by the explosion, and do not penetrate more than half the number of sheets. Now three or four pellets are useless; and what the sportsman must rely on is the performance of the whole of the central pellets of his charge, which the new test measures accurately. Mr Green did wonders with reduced charges of powder and shot; and we believe it will be proved hereafter that of late the charges generally adopted have been considerably too large; but we may remark that there are two sides to this question, as Mr Jeffries's and Mr Jones's high figures were obtained under exactly the opposite conditions.

Up to the year 1878, in estimating the merits of a gun, it was considered expedient to combine pattern and strength of shooting in equal proportions, both being *desiderata* of similar value, and usually as one was gained the other was lost. Hence, up to that time the figure of merit was compounded in such a way as to make the two subordinate one to the other—the method adopted being to count the pellets of shots striking within a 30in. circle for the one, and the number of sheets of brown paper pierced, multiplied by six, for the other. This multiplication was suggested as a means of raising the "penetration," as it was technically called, to about an equal position with the pattern, without which the latter would have been "all in all." Prior to the 1878 trial, however, choke-boring came fully into play, by which it was rendered apparent that any desired pattern up to 230 might be obtained; and for this reason we then abandoned pattern, pure and simple, as an element in the figure of merit, and instead of it adopted its variation as an adjunct to penetration, considering uniformity of pattern as the one thing needful to make the gun a reasonably perfect piece of mechanism. This conclusion was arrived at in consequence of the wild shots which so often occurred in testing the choke-bore, and which, of course, led to frequent "misses" in the field, without any fault on the part of the sportsman. In 1878 this was fully tested, and, with a few exceptions, it was found that our anticipations were realised. In addition to these two essentials, we also tested the amount of recoil by means of a Salter's balance, and at the same time the "putting together" of the barrels, through the agency of the machine rest which we had recently invented, and used for the first time at that trial. This machine not only does away with the influence on the results of the human shooter, whose skill was often supposed to be the cause of success rather than the boring of the gun, but it also shows whether the barrels are properly "put together," penalising them severely if they are not—because both cannot then be made to shoot at the centre of the target, and all that can be done is to humour them by a compromise, as was done in many instances last week. In 1878 we fully tested this machine rest, and all the competitors were perfectly satisfied with its performance, so that it was unanimously accepted as the best means of testing the gun in a public trial; and this reputation it fully maintained last week.

We may also mention that, during the interval between the trial of 1878 and that just concluded, we had demonstrated by experiment that the cause of the wild shots alluded to above resides in the chambering and in the wads used, and had published a method of loading which almost completely prevents their occurrence.

But we had still one defect to overcome, consisting in the "rough-and-ready" means adopted for testing penetration, or, as we now call it, "force." It consisted, as is well known, in the use of pads of brown paper fixed in front of the target, the penetration being measured by the number of sheets pierced by three pellets—as it was practically impossible to trace all the pellets throughout the sheets and take the average penetration, which is what ought to be done; for of course three pellets are not of much use in a space 10in. square, or 100 square inches. In addition to this defect, brown paper, even of a fixed quality and weight, differs greatly in thickness and hardness, and is also affected by the weather, so that it could only be relied on approximately as a means of comparison. After trying to induce the gunmakers themselves to invent some better test, we hit on one ourselves, which, with the aid of improvements suggested by Mr. Green and Mr. Jones, now gives most reliable results, and measures the average force per pellet in a manner which gave perfect satisfaction to all the competitors. The plan adopted is in principle that of the machine described in the *Field* on Jan. 25, 1879, the improvements consisting in the adoption of a different steel for the plate, and in the use of a different tell-tale, which, by means of a vulcanite point, wipes out the black paint spread on a white plate of glass, leaving a well-defined white line to indicate the extent of the movement of the lever. At 40 yards this tell-tale is perfectly reliable, but at 60 it occasionally appears to err, from some cause or other; but still even then it gives far better results than brown paper—and, moreover, its indications are similar at all times, so that in future we can take the figures of merit of 1879 as a *datum* line with which to compare other guns by means of the new test. [The article descriptive of the force-gauge is given subsequently (page 120).]

Lastly, we should mention that we slightly altered the recoil test by screwing up the Salter's balance to 60lb. instead of 30lb., as we found the accuracy of shooting greatly increased thereby. This necessitated the alteration of the 50lb. deduction to 80lb. before estimating the recoil.

The conditions under which the trial was carried out were as follows, including several slight alterations:

1. The entries to be confined to gunmakers; and in each class every competitor to enter one gun, and no more. The entrance fee for each gun to be 5 guineas. The Editor of the *Field* to be the manager, and his decisions on all points to be final.

2. The competition to be at the ground of the All England Croquet and Lawn Tennis Club, near Wimbledon station, commencing at ten o'clock on Monday, April 28, and continuing daily from the same hour till completed. The guns to be shot from the *Field* machine rest, in order according to lot. The competitor first drawn will shoot his 12-gauge, to be followed by that of the competitor who draws the second lot. Competitor No. 1 will then shoot his 16-gauge, to be followed by competitor No. 2, and so on to the 20-gauges; after which competitors No. 3 and 4 will follow in the same order.

3. Every competitor to forward to the manager the trade number and weight of his guns before the trial, stating also the maker of the powder and shot he intends using, together with the number of the respective make of powder selected. The powder to be furnished by the manager, and to be black powder of English make.

4. The guns to be divided into three classes, as follows:

Class I.—For 12-gauges, or under, weight not to exceed 7½lb.
Class II.—For 16-gauges, and under, weight not to exceed 6¾lb.
Class III.—For 20-gauges, and under, weight not to exceed 6lb.

In each class any kind of boring will be allowed; but the patterns must be declared for 40 yards range prior to the trial, and the figure of merit will be in that respect founded on such declaration. These patterns must not be less, at 40 yards, than 150 for Class I., 140 for Class II., and 130 for Class

III. The competitors must also declare the material of their barrels, that is to say, whether English or foreign, and whether Damascus or laminated iron; and, if this is incorrectly given, the gun so described to be disqualified.

5. The cartridge cases to be furnished by the competitors, and delivered empty to the manager at the time of trial, for loading in his presence; they must be of the ordinary paper kind. The wadding to be furnished at the same time, and it also must be of felt or paper, as ordinarily sold.

6. The shot to be No. 6, either Lane and Neasham's soft shot or their hard shot, or the chilled shot manufactured by the Newcastle Chilled Shot Company—about 270 pellets per ounce—to be found by the manager. The charges not to exceed 1⅛oz. for the 12-bores, and 1oz. for the 16-bores and 20-bores; all by weight, to be verified at the time of loading. The loading to be done by the competitors, in the presence of the manager, immediately before or during each trial, and the cases to be properly turned over to the satisfaction of the manager. The charge of powder must be declared before the trial.

7. Every gun to be fired twenty-five rounds at 40 yards range; and the six highest in each class to be then fired at 60 yards, also twenty-five rounds. If the competition in the first round extends to more than one day, the six are to be selected from those making the highest score in each day, according to the plan adopted in the trial of 1875.

8. The figure of merit to be made up of penetration, pattern, and recoil as follows: The penetration to be computed according to the force per pellet indicated on the force gauge, described in the *Field* of Jan. 25, 1879.

The pattern to be computed according to the average deviation of each of the twenty-five patterns made from the declared pattern, which average deviation is to be deducted from the penetration. At 60 yards the deviation to be computed from the average pattern.

The average recoil above 80 to be deducted, and also the difference in recoil.

The final figure of merit to be computed from the totals of the two figures made respectively at 40 and 60 yards.

9. The whole of the entrance moneys to be divided into nine equal parts, two of which are to be given to the gun making the highest combined figure of merit in each class, and one to the second highest, without any deduction whatever.

10. The proprietors of the *Field* agree to bear all the charges of the trial.

11. The manager reserves to himself the right to make any slight deviation from the above plan which may be considered expedient by three of the competitors, and which he himself approves of, without taking a vote.

Only four pairs of barrels were entered as of Belgian make, viz., all Messrs. Bland's and one of Mr. Green's. The former, we were assured by the firm, were entered to show that they had "the courage of their opinions," which are that the foreign barrels are as good as the English in every respect, and superior in freedom from "greys," &c. All their guns were veritable "keepers' guns," as admitted by the several competitors, and were selected from ordinary stock, so that it is scarcely fair to take them as testing the value of the two kinds; and looking at them as cheap guns, not got up regardless of cost, as was the case generally, their performance was highly creditable; indeed, the 16-bore at sixty yards shot marvellously well, being third on the whole list of twenty-one guns. We must therefore fall back on Mr. Green, whose 20-bore (Belgian) beat his 16-bore (English) at 40 yards, but was beaten by the latter considerably at 60 yards—so much so as to turn the tables in the final figure of merit compounded of the two. The result of the experiments we have ourselves made, and of the information gained from the most impartial and reliable sources, is that, on the average, barrels of Birmingham make give the strongest shooting, and, *moreover, keep it considerably longer*, but that the very best samples of Belgian barrels are little, if at all, inferior to the English.

In accordance with No. 7 of the conditions, we selected for the second round those guns which had made the highest figures on each day, in proportion to the numbers shot. This was also in accordance with our 1875 practice, and was founded on our experience that, with our variable climate, it is impossible to compare fairly together guns fired on different days; but, as it happened, there was last week very little variation from day to day. A gentle leading breeze blew all through the week, slightly increased on Friday, which favoured the guns shot on that day at 60 yards; but on Saturday, when Mr. Green's two winning guns were shot, and also Mr. Malcham's three, there was almost a dead calm. Several guns made higher scores than the final six at 40 yards, owing to the above cause, including those of Mr. Rosson and Mr. Birkett, which, without the above explanation, would be apparently an anomaly, and by the excluded competitors was, of course, regarded as a hardship, but, being in accordance with the conditions, it was wholly unavoidable. Even with our canvas screen, the difference between a head wind and a leading wind would make at least a variation of 15 or 20 per cent. in force; and we could not expect the same wind for a whole week, although it really so happened.

In analysing the performances of the several guns, we find that in the 12-bores Mr. Greener maintained his position of 1875 and 1878, but by 3 points only, beating Mr. Lincoln-Jefferies in nearly the same proportion at the two distances. In the second class, for 16-bores, Mr. Green distanced all his competitors in all the three classes, beating Mr. Greener's 12-bore by 32·28 points—a most marvellous performance truly. Contrary to our expectation, and that of all the gunmakers with whom we had conversed, the difference in force, which was in favour of the 12-bore at 40, was the reverse at 60 yards, Mr. Green's gun making an average per pellet of 111·24, whereas Mr. Greener's 12-bore only scored 104·40. With his 20-bore, however, Mr. Green fell off to 80·16, owing, most probably, to his very small charge of powder; but his patterns were marvellously regular, the average of the deviations being only 9·32. In the 3rd class, for 20-bores, Mr. Green again beat the winning 12-bores, but by only 1·68. Not only Mr. Green's small-bores, however, but Mr. Malcham's 16-bore, head the 12-bores in figure of merit; but still at 40 yards it will be seen that the superiority in penetration rested with the latter on the average, as well as in a large proportion of individual cases. Still, taking into consideration all the elements making up a good gun, the 16-bore had considerably the best of the trial as compared with the 12-bore, and the 20-bore to a slight extent. This was quite unexpected, even by Colonel Whyte, who has long advocated the use of the small-bores, which since the days of Joe Manton have been almost wholly neglected until within the last year or two. The above celebrated maker preferred the 18-bore to all others, and probably it would be found more suitable to the general requirements of the sportsman than the 20-bore, as it can be made very nearly of the same weight. Clearly, however, an average good shot may dispense with nearly a pound in the weight he has to carry, for the 16-bore may be made to weigh considerably less than 6½lb., and the 20-bore still lighter. A decidedly bad shot must still burden himself with a gun which will produce a larger pattern; but the killing distance is nearly the same in all three gauges, and the little "pop-gun" can no longer be "pooh-poohed" as a toy. We confess that we went into the trial with a conviction that the small-bores had no chance; but we congratulate ourselves that we nevertheless took every pains to give them fair play, and we rejoice that our efforts have not ended in proving the truth of a foregone conclusion.

Charges Used by the Different Makers.	12-bore. (1⅛oz.)	16-bore. (1oz.)	20-bore. (⅞oz.)
Birkett, T., Birmingham.—P. & W. No. 4	3½drs.	3¼drs.	2¾drs.
Bland and Sons, London.—C. & H. No. 6	3 „	2¾ „	2¼ „
Green, E.C., Cheltenham.—C. & H. No. 6, No. 4, and basket grain	3* „	2¾* „	2* „
Greener, W. W., Birmingham.—P. & W. No. 4	3¼ „	2¾ „	2½ „
Jeffries, L., Birmingham.—C. & H. No. 4	3¼ „	2¾ „	2½ „
Jones, W. H., Birmingham.—C. & H. No. 4 Diamond	3½ „	3 „	2¼ „
Leeson, W. R., Ashford.—C. & H. coarse-grain basket	3¼ „	2¾ „	2¾ „
Malcham, C. H., Sheffield.—C. & H. No. 6	3 „	2¼ „	1¾ „
Rosson, C., Derby.—P. & W. No. 4	3¼ „	2¾ „	2¼ „
Thomson and Son, Edinburgh.—C. & H. No. 6	3 „	2¾ „	2 „
Tisdall, W. H., Birmingham.—C. & H. No. 4	3¼ „	2½ „	2½ „
Trulock and Harriss, Dublin.—P. & W. No. 4	3⅛ „	2¾ „	2¼ „

The charges of shot generally used were 1⅛oz. of No. 6 chilled with 12-bores, 1oz. with 16-bores, and ⅞oz. with 20-bores. There was one exception, however, as Mr. E. C. Green used ⅛oz. less in the two larger bores, but not in the 20-gauge. He also employed different powders in the three bores, viz., 3drs. of Curtis and Harvey's No. 6 and 1oz. of shot in the 12-bore; 2½drs. of their No. 4 and ⅞oz. in the 16-bore; and 2drs. of their coarse-grain basket powder, with ⅞oz. shot, in the 20-bore.

[In the original report of these trials, particulars of the whole of the rounds fired from the thirty-six guns, at the respective distances, were given in full. But in the following summary only the averages of the twenty-five rounds are given, together with the highest and lowest of the series, in order to show the greatest extent of variation. As the amount of "penetration" was the principal factor in estimating the "figure of merit" (and deductions were made for irregularities, as compared with the "declared pattern" previously announced by the maker of the gun), we arrange the guns in the order of the "force per pellet" exhibited by them; and the extent of variation will be seen by comparing the records of the highest and lowest rounds. After the amount of "force" recorded, there is stated, in *italic* figures, the number of pellets by which the record was made. This will enable the reader to form his own opinion as to the correctness of the allegation which has been made, that the force-gauge favours guns which use small charges of powder and place a large number of pellets on the plate. In the 60 yards records, however, there are a few instances where the figures appear erroneous. One pellet could scarcely give 3·00 force at 60 yards; for there could be no "balling" with a single pellet.—T.]

12-BORE GUNS, AT 40 YARDS.

Maker of Gun.	Powder. Drs.	Force per Pellet. Average.	Highest.	Lowest.	Pattern. Aver.	High.	Low.
Jeffries ...	3¼	2·39 (52)	2·84 (85)	2·07 (44)	210	252	88
Greener ..	3¼	2·31 (50)	2·70 (66)	1·93 (43)	204	241	149
Jones.....	3¼	2·29 (41)	2·67 (21)	2·02 (43)	187	230	114
Trulock ..	3¼	2·25 (53)	2·63 (59)	1·69 (74)	212	250	137
Leeson ...	3¼	2·25 (36)	2·47 (34)	1·55 (9)	174	219	61
Rosson ...	3¼	2·23 (48)	2·47 (68)	2·04 (52)	207	257	117
Maleham.	3	2·22 (56)	2·71 (70)	1·96 (67)	224	255	130
Green ...	3*	2·14 (45)	2·60 (52)	1·33 (9)	183	232	50
Birkett...	3¼	2·14 (34)	2·47 (36)	1·78 (9)	175	216	92
Thomson	3	2·07 (34)	2·60 (20)	1·83 (52)	162	215	93
Bland	3	2·02 (56)	2·43 (70)	1·77 (65)	223	256	140
Tisdall ...	3¼	2·01 (44)	2·21 (44)	1·73 (30)	180	210	141
General Aver...		2·19 (45)			195		

16-BORE GUNS, AT 40 YARDS.

Maker of Gun.	Powder. Drs.	Force per Pellet. Average.	Highest.	Lowest.	Pattern. Aver.	High.	Low.
Maleham	2¼	2·26 (45)	2·80 (10)	2·00 (24)	190	219	89
Green ...	2¼*	2·24 (39)	2·58 (33)	2·02 (46)	170	200	130
Jeffries...	2¾	2·23 (39)	2·55 (31)	1·96 (51)	174	208	116
Birkett...	3¼	2·22 (29)	2·89 (9)	1·81 (26)	145	175	107
Leeson ...	2¾	2·19 (33)	2·48 (31)	1·30 (15)	153	185	95
Jones.....	3	2·18 (38)	2·48 (27)	1·67 (48)	166	211	72
Greener ..	2¾	2·15 (34)	2·73 (15)	0·88 (17)	161	197	99
Trulock ..	2¾	2·12 (30)	2·53 (17)	1·52 (33)	144	194	87
Tisdall ...	2¼	2·10 (35)	2·39 (28)	1·87 (16)	157	196	108
Thomson	2¾	2·10 (30)	2·42 (33)	1·61 (21)	150	181	98
Rosson ...	2¾	2·07 (34)	2·59 (17)	1·64 (25)	157	194	106
Bland ...	2¾	2·03 (35)	2·33 (27)	1·62 (52)	166	201	92
General Aver...		2·16 (35)			161		

20-BORE GUNS, AT 40 YARDS.

Maker of Gun.	Powder. Drs.	Force per Pellet. Average.	Highest.	Lowest.	Pattern. Aver.	High.	Low.
Rosson ...	2½	2·30 (31)	2·69 (13)	2·03 (35)	150	195	91
Greener ..	2¾	2·24 (31)	2·64 (22)	1·93 (41)	152	189	93
Green	2	2·24 (32)	2·52 (25)	2·03 (33)	151	172	133
Leeson ...	2¾	2·22 (33)	2·77 (13)	1·94 (32)	157	193	93
Birkett ...	2¼	2·18 (31)	2·54 (13)	1·73 (26)	152	187	100
Jones	2¼	2·16 (34)	2·42 (38)	1·50 (10)	160	194	86
Jeffries ...	2½	2·09 (40)	2·39 (49)	1·74 (31)	173	208	120
Thomson.	2	2·08 (26)	3·00 (14)	1·36 (11)	122	166	62
Tisdall....	2½	2·07 (36)	2·41 (28)	1·81 (42)	157	199	123
Maleham.	1¾	2·05 (43)	2·29 (24)	1·85 (47)	184	210	114
Bland	2¼	1·92 (40)	2·23 (26)	1·35 (31)	174	206	103
Trulock...	2¼	1·77 (30)	2·40 (20)	0·60 (5)	133	195	65
General Aver...		2·11 (34)			155		

12-BORE GUNS, AT 60 YARDS.

Maker of Gun.	Powder. Drs.	Force per Pellet. Average.	Highest.	Lowest.	Pattern. Aver.	High.	Low.
Jeffries ...	3¼	1·01 (16)	1·35 (17)	0·40 (5)	99	131	66
Greener ..	3¼	1·04 (17)	1·41 (27)	0·21 (14)	98	124	78
Maleham.	3	1·01 (19)	1·32 (19)	0·31 (13)	101	127	70
Rosson ...	3¼	0·98 (16)	1·37 (24)	0·57 (7)	90	124	55
Leeson ...	3¼	0·94 (14)	1·41 (17)	0·33 (12)	88	115	56
Trulock...	3¼	0·84 (15)	1·46 (28)	0·17 (12)	82	111	46
Tisdall ...	3¼	0·69 (12)	1·20 (15)	0·15 (13)	73	105	23
General Aver...		0·94 (16)			90		

16-BORE GUNS, AT 60 YARDS.

Maker of Gun.	Powder. Drs.	Force per Pellet. Average.	Highest.	Lowest.	Pattern. Aver.	High.	Low.
Green	2¼*	1·11 (15)	1·69 (13)	0·38 (8)	81	101	62
Bland	2¾	1·02 (15)	1·47 (17)	0·20 (10)	88	107	26
Maleham.	2¼	1·00 (16)	1·27 (22)	0·70 (10)	92	121	73
Jones.....	3	0·97 (11)	6·00 (7)	0·22 (9)	70	145	31
Jeffries ...	2¾	0·79 (10)	1·33 (3)	0·27 (11)	67	96	29
Leeson ...	2¾	0·77 (13)	1·31 (13)	0·27 (11)	74	92	39
Tisdall ...	2½	0·71 (11)	3·00 (1)	0·14 (5)	66	103	36
General Aver...		0·91 (13)			77		

20-BORE GUNS, AT 60 YARDS.

Maker of Gun.	Powder. Drs.	Force per Pellet. Average.	Highest.	Lowest.	Pattern. Aver.	High.	Low.
Maleham.	1¾	0·93 (14)	1·24 (21)	0·44 (9)	85	107	53
Green ...	2*	0·80 (11)	1·39 (18)	0·38 (8)	67	87	32
Tisdall ...	2½	0·77 (8)	3·00 (1)	0·22 (9)	54	78	33
Jones.....	2¼	0·74 (12)	1·43 (21)	0·20 (5)	74	112	32
Greener ..	2¼	0·70 (13)	1·29 (14)	0·25 (12)	68	99	46
Leeson ...	2¾	0·63 (9)	1·29 (14)	0·22 (9)	62	91	33
Bland.....	2¼	0·61 (11)	1·14 (7)	0·33 (15)	70	100	38
General Aver...		0·74 (11)			68		

We append the following table, which is of great interest to those who desire to compare the performances of the three bores, as made by the different gunmakers:

GUNS IN THEIR ORDER OF MERIT DIVIDED INTO THE THREE CLASSES.

[The numbers at the beginning of the lines show the order on the total of both distances; those in the middle show the order at 40 and 60 yards respectively.]

12-Bores.	Figure of Merit. 40 yards.	60 yards.	Total.
1. Greener	(1) 172·64	(1) 61·60	234·24
2. Lincoln Jeffries	(2) 171·44	(2) 59·80	231·24
3. Rosson	(3) 161·20	(4) 52·04	213·24
4. Leeson	(4) 158·76	(5) 47·12	205·88
5. Maleham	(6) 146·48	(3) 58·96	205·44
6. Trulock and Harriss	(7) 137·58	(6) 32·44	170·02
7. Tisdall	(5) 148·06	(7) 13·52	161·58

16-Bores.	Figure of Merit. 40 yards.	60 yards.	Total.
1. Green	(1) 184·84	(1) 81·68	266·52
2. Maleham	(3) 171·24	(2) 71·52	242·76
3. Jones	(4) 171·12	(4) 56·32*	227·44
4. Lincoln Jeffries	(2) 175·20	(6) 38·72	213·92
5. Bland	(7) 143·00	(3) 68·24	211·24
6. Leeson	(5) 166·40	(5) 40·76	207·16
7. Tisdall	(6) 152·96	(7) 33·52	186·48

* Jones's 16-bore at 60 yards, No. 20 shot R.B., marked 42 on gauge, with 7 pellets, giving average of 6·00. If he were credited with 3·00 (the highest figure made at 60 yards by any single shot) his figure of merit for 60 yards would stand at 44·32; total 215·44.

20-Bores.	Figure of Merit. 40 yards.	60 yards.	Total.
1. Green	(1) 187·32	(2) 48·60	235·92
2. Maleham	(4) 165·80	(1) 66·44	232·24
3. Greener	(2) 173·04	(5) 27·00	200·04
4. Leeson	(3) 168·96	(6) 25·04	194·00
5. Jones	(5) 163·12	(4) 30·44	193·56
6. Tisdall	(6) 159·24	(3) 33·04	192·28
7. Bland	(7) 131·84	(7) 22·76	154·60

GUNS IN ORDER OF MERIT, the three classes being mixed.—(1). 40 Yards.

Maker.	Bore.	Figure of Merit.	Maker	Bore.	Figure of Merit.
1. Green*	20	187·32	19. Birkett	16	156·12
2. Green*	16	184·84	20. Jeffries	20	155·03
3. Jeffries*	16	175·20	21. Green	12	154·80
4. Rosson	20	174·44	22. Birkett	20	154·36
5. Greener*	20	173·04	23. Tisdall*	16	152·96
6. Greener*	12	172·64	24. Rosson	16	151·92
7. Jeffries*	12	171·44	25. Jones	12	149·36
8. Maleham*	16	171·24	26. Tisdall*	12	148·06
9. Jones*	16	171·12	27. Thomson	12	147·88
10. Leeson*	20	168·96	28. Maleham*	12	146·48
11. Leeson*	16	166·40	29. Birkett	12	143·56
12. Maleham*	20	165·80	30. Bland*	16	143·00
13. Greener	16	164·56	31. Trulock & Harriss*	12	137·58
14. Jones*	20	163·12	32. Trulock & Harriss	16	133·16
15. Rosson*	12	161·20	33. Bland*	20	131·84
16. Tisdall*	20	159·24	34. Bland	12	105·50
17. Leeson*	12	158·76	35. Trulock & Harriss	20	102·50
18. Thomson	20	156·56	36. Thomson	16	—

* Guns shot at 60 yards range.

(2) 60 Yards.

Maker.	Bore.	Figure of Merit.
1. Green	16	81·68
2. Maleham	16	71·52
3. Bland	16	68·24
4. Maleham	20	66·44
5. Greener	12	61·60
6. Jeffries	12	59·80
7. Maleham	12	58·96
8. Jones	16	56·32
9. Rosson	12	52·04
10. Green	20	48·60
11. Leeson	12	47·12
12. Leeson	16	40·76
13. Jeffries	16	38·72
14. Tisdall	16	33·52
15. Tisdall	20	33·04
16. Trulock & Harriss	12	32·44
17. Jones	20	30·44
18. Greener	20	27·00
19. Leeson	20	25·04
20. Bland	20	22·76
21. Tisdall	12	13·52

(3) Totals of 40 and 60 Yards.

Maker.	Bore.	Figure of Merit.
1. Green	16	266·52
2. Maleham	16	242·76
3. Green	20	235·92
4. Greener	12	234·24
5. Maleham	20	232·24
6. Jeffries	12	231·24
7. Jones	16	227·44
8. Jeffries	16	213·92
9. Rosson	12	213·24
10. Bland	16	211·24
11. Leeson	16	207·16
12. Leeson	12	205·88
13. Maleham	12	205·44
14. Greener	20	200·04
15. Leeson	20	194·00
16. Jones	20	193·56
17. Tisdall	20	192·28
18. Tisdall	16	186·48
19. Trulock & Harriss	12	170·02
20. Tisdall	12	161·58
21. Bland	20	154·60

In addition to the comparative performances of the guns themselves, it is also desirable to investigate the relative value of different powders and loads of shot. All the competitors used 1¼oz. shot with the 12-bores, except Mr. Green, who used only 1oz. All used 1oz. shot with the 16-bores and 20-bores except Mr. Green, who limited his load to ⅞oz. in both, with 3drs. of powder in the 12-bore, and 2¼drs. and 2drs. respectively in the 16 and 20-bores. His success with these reduced loads is worthy of remark, and sportsmen in future will have to consider whether or no they can improve their shooting by following his example. Our own opinion has for some time been that the loads have been overdone, and, without doubt, the recent trial tends to confirm it. It appears that a mistake was made in entering Mr. Green's declared pattern of his 20-bore as 165, whereas we have the strongest evidence of the members of our staff that he gave it as 155. If so it would raise his figure of merit at 40 yards to 194·12 from 187·32, and his final figure in a corresponding proportion, viz., from 235·92 to 242·72.

12-BORE AVERAGES.

	Drs.	40 Yards. Penet.	Recoil over 80lb.	Pattern.	Declared Pattern.	Figure of Merit.	60 Yards. Penet.	Recoil over 80lb.	Pattern.	Figure of Merit.	Final Fig. of Merit
Greener ...	3½	231·20	31·24	204·20	200	172·64	104·40	27·92	97·52	61·60	234·24
Jeffries ...	3½	238·72	31·64	209·80	200	171·44	109·20	29·64	98·72	59·80	231·24
Rosson.....	3½	223·12	29·28	206·84	200	161·20	98·16	25·36	89·68	52·04	213·24
Leeson ...	3½	225·32	31·52	174·00	200	158·76	93·92	28·52	87·68	47·12	205·88
Green	3	213·52	19·20	183·24	190	154·80					
Jones	3½	228·68	38·16	187·44	203	149·36					
Tisdall.....	3½	200·68	32·18	179·64	180	148·06	69·36	29·44	73·24	13·52	161·58
Thomson...	3	207·08	22·40	161·76	180	147·88					
Malcham...	3	222·00	27·20	224·48	200	146·48	100·68	19·76	100·68	58·96	205·44
Birkett ...	3½	213·52	38·52	174·92	200	143·56					
Trulock & Harriss..	3½	224·52	36·62	211·80	182	137·58	84·12	27·96	82·00	32·44	170·02
Bland	3	201·56	27·30	223·12	175	105·50					

16-BORE AVERAGES.

	Drs.	40 Yards. Penet.	Recoil over 80lb.	Pattern.	Declared Pattern.	Figure of Merit.	60 Yards. Penet.	Recoil over 80lb.	Pattern.	Figure of Merit.	Final Fig. of Merit
Green	2¼	224·44	19·24	170·36	165	184·84	111·24	15·28	80·80	81·68	266·52
Jeffries	2¾	222·80	26·56	174·00	171	175·20	79·60	24·28	67·40	38·72	213·92
Malcham ..	2¼	226·40	20·48	189·96	190	171·24	99·64	15·00	92·28	71·52	242·76
Jones	3	217·76	26·72	166·16	170	171·12	96·88	22·84	70·28	56·32	227·44
Leeson.....	2¾	218·76	25·60	153·40	170	166·40	76·64	21·60	74·08	40·76	207·16
Greener	2¾	215·12	26·32	161·48	175	164·56					
Birkett.....	3¼	222·12	29·80	144·80	175	156·12					
Tisdall.....	2¼	210·28	27·40	157·12	165	152·96	70·68	16·96	66·44	33·52	186·48
Rosson	2¾	206·80	25·00	157·04	175	151·92					
Bland	2¾	202·88	23·76	166·48	157	143·00	101·68	14·68	87·76	68·24	211·24
Trulock & Harriss...	2¾	211·64	32·96	143·92	180	133·16					
Thomson ..	2¾	207·08	28·80	161·76	180	147·88					

20-BORE AVERAGES.

	Drs.	40 Yards. Penet.	Recoil over 80lb.	Pattern.	Declared Pattern.	Figure of Merit.	60 Yards. Penet.	Recoil over 80lb.	Pattern.	Figure of Merit.	Final Fig. of Merit
Green	2	224·48	15.32	150·72	165	187·32	80·16	14·24	67·28	48·60	235·92
Rosson ...	2¼	229·64	21·64	150·16	165	174·44					
Greener ..	2⅝	223·88	21·60	152·20	168	173·04	70·36	21·00	68·44	27·00	200·04
Leeson.....	2¾	222·24	26·92	157·12	150	168·96	63·48	22·84	61·60	25·04	194·00
Malcham...	1¾	204·92	8·88	183·80	170	165·80	92·84	10·80	84·68	66·44	232·24
Jones	2¼	216·00	24·48	160·00	174	163·12	73·96	20·06	74·00	30·44	193·56
Tisdall.....	2¼	206·60	23·08	157·12	155	159·24	77·04	25·08	53·60	33·04	192·28
Jeffries ...	2¼	209·24	23·20	173·16	156	155·08					
Thomson .	2	208·40	10·68	122·16	135	156·56					
Birkett ...	2¼	217·80	26·60	151·72	180	154·36					
Bland	2¾	191·76	14·96	174·00	145	131·84	61·40	17·56	70·28	22·76	154·60
Trulock & Harriss ..	2¾	176·72	25·22	139·96	161	109·50					

THE "FIELD" SHOT-GUN FORCE GAUGE.

(*Field*, Jan. 25, 1879; Vol. 53, p. 82.)

HAVING made several alterations in the machine which we have constructed for gauging the average force of the pellets of shot as they reach the ordinary plate used by gunmakers, at any distance which may be desired, we here publish a plan of the gauge as used at the 1879 trial.

The chief difficulty which we have met with is in the construction of the movable 10in. target (*a a*), from which the force of the pellets striking it is registered. We made this at first of cast steel, 23-gauge, turned over at two of its edges; but we soon found that the steel buckled forward and became cupped, so as to deflect the shot. We now find that it must be of 17-gauge steel, turned forward at the edges when hot, in which shape it stands well. To reduce the weight to 2lb., which is the lowest possible, we dispense with the wood backing, except in the middle, as shown in the engraving. To aid in this respect, the wooden platform (*b*), which is 3in. wide, is also reduced between the points of suspension. This movable target is suspended by four flat parallel rods (*c c*), two on each side, by which the plate (*a a*) is kept upright, and when struck moves back on the short arm of the lever (*f*), which is of steel, the friction being reduced by a small steel roller. The long arm (*g*) is of wood (beech, ash, or mahogany—we prefer beech, on account of its toughness), attached to the short arm by small screws or rivets. Between the two arms is the centre (*h*), on which they move freely, but the socket must be deep enough to ensure truth in the working. At the other end of the long arm, the wood is cut into a shape suited to receive a chisel-edged pointer, made of vulcanite, which bears on a white enamelled glass plate, and traverses it from end to end. This plate is covered below the scale (*l l*) with lamp black and oil, and as the lever moves under the blow of the shot the vulcanite point wipes out the black, leaving a white line, as shown in the engraving. Of course the paint must be carefully renewed after each shot. The parallel rods are attached above to a wooden rectangular frame of mahogany (*d, d, d, d*), 3in. wide, one side of which, 15in. long, is capable of being attached to the front of the gunmaker's plate by the clip and thumb screw (*e, e*). The lowest side of this frame, to which the parallel rods are attached, is cut away in the middle for the brass frame (*o*), to which the lever is attached by the centre (*h*), already mentioned, and on which it plays, and the front is protected by sheet iron. The springs (*i j*) are of Salter's make, and are attached so that the upper one (*i*) draws the lever against the plate, while (*j*) takes the main blow. The scale (*l l*) is constructed on the plan to be presently described.

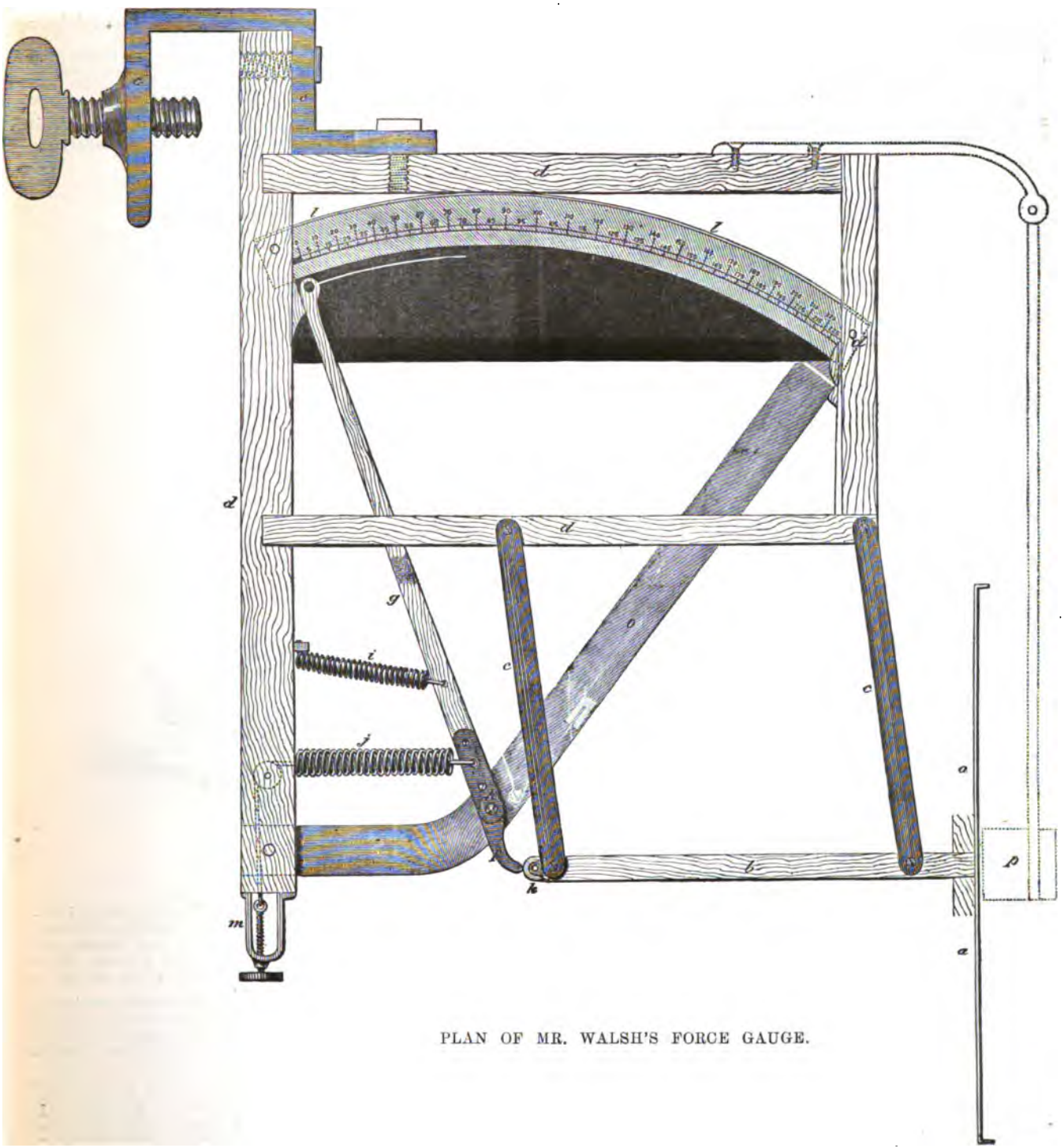
Lastly, a point of suspension for the test hammer (*p*) is provided, which must be exactly 12in from the centre of the target, and should be made so that the handle of the hammer cannot be raised above the horizontal position, by means of a check at the joint, which should be of metal, to which the wooden handle is socketed This handle must be of deal, and as thin and light as is possible. Of course, after the test the hammer is removed.

To set out the scale, or to test it subsequently, several hammers should be made of ash, the heads of which weigh respectively 2oz., 4oz., 8oz., 16oz., and 24oz., *deducting from each half the weight of the handle*, which we find to be ½oz. Each should be raised till the handle is horizontal, and then let fall freely one foot till it strikes the plate. The blow of the 2oz. hammer causes the pointer to leave a white mark opposite the part marked 16 on the scale, or eight times its weight. The 4oz. marks 32, the 8oz. 64, and so on, and by the aid of this setting out the whole scale is easily made, and the gauge afterwards regulated by adjusting the springs.

In the trials of 1879 we used a sheet of paper to record the patterns, stretched over the 10in. plate. A flange of iron projected a little beyond this plate above and below, so as to prevent the paper from pressing upon it. By blackening the edges of the plate after each shot, and pressing it forward against the paper guarded by the band, a black line was left, which indicated the number of pellets striking the plate. If whitewash is used, the open frame (*d, d, d, d*) must be closed by means of a wooden door behind and before, so as to protect the working parts from the splashes of whitewash, which increases the friction wherever it touches.

In using the machine, the force registered by the shot must be divided by the number of pellets striking the 10in. plate. Thus supposing 46 pellets strike the plate, and the index registers 76, as in the engraving, then, by adding two noughts to the latter and dividing by 46, we get 1·65 as the average force per pellet. W.

[To estimate the velocity of the shot on striking the plate, multiply the record of force by the number of pellets per ounce: thus, 1·65 × 270=445ft. per second.—T.]

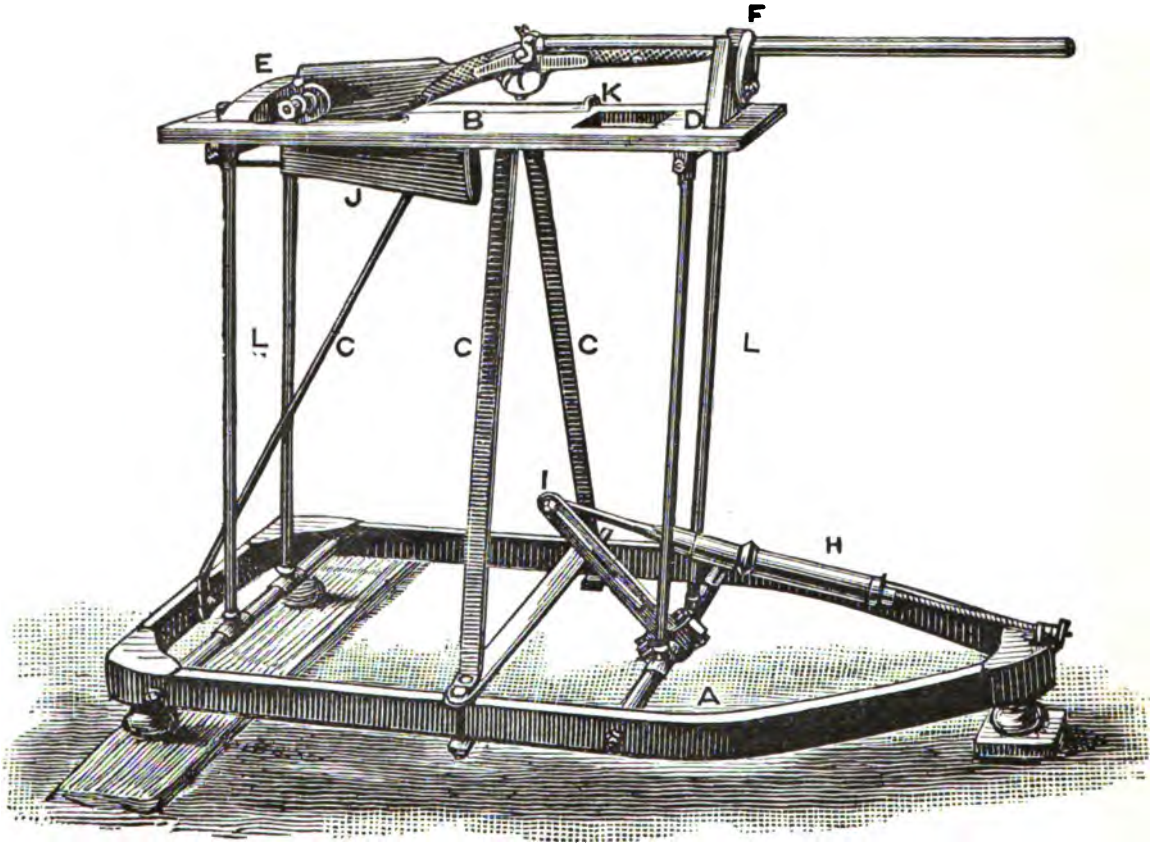


PLAN OF MR. WALSH'S FORCE GAUGE.

PHILLIPS'S GUN-REST AND RECOIL-GAUGE.

(*Field*, Sept. 20, 1890; Vol. 76, p. 461.)

THE woodcut herewith inserted gives a representation of a new gun-rest which we have had constructed for experimental purposes. It has been devised with the double object of holding the gun steadily during its trial at the target, and of at the same time registering the energy of recoil in a more conclusive manner than has hitherto been done. The machine-rest invented by the late Mr. Walsh, for use in the *Field* Gun Trials (see page 111), although possessed of excellent qualities in some respects, was in others not entirely satisfactory. Being constructed mainly of wood, there was a liability to get out of order from exposure to damp, while it was not sufficiently portable to meet the ordinary requirements of gunmakers; and although the spring which served to check the backward movement of the gun had



PHILLIPS'S MECHANICAL GUN-REST AND RECOIL-GAUGE.

the scale of pounds usually attached to spring balances, so that some comparison could be made between the degrees of recoil exhibited by guns tried with different explosives, or with variations in charges of powder and shot, yet no definite dynamic value could be assigned to recoil records based on the static "pounds" marked on the scale of the spring balance, as the resistance of the spring is not constant, but increases with each notch on the scale; and no allowance was made for variation in the weight of the gun. Consequently, absolute comparison could not be made between the amount of energy indicated by the velocity of a shot-charge, and that exhibited by the recoil of the gun from which the charge had been fired.

The new mechanical rest is constructed almost entirely of iron, and thus is rendered comparatively light and portable; and, inasmuch as the energy of the gun's recoil is indicated by definite weights being lifted or moved through measured amounts of space, the records thus obtained are convertible into "foot-pounds" of work done. Hence, comparisons may be made between theoretical statements of recoil, calculated in accordance with principles laid down in text books on gunnery, and actual recoil records, obtained by the practical process of firing charges of powder and shot, so as to simultaneously ascertain, by chronograph and recoil-gauge, what the forward velocity of the shot and the backward movement of the gun respectively amount to.

This gun-rest (which has been designed by Mr. H. F. Phillips, a member of the *Field* staff) may be described as follows:

Near to the ground is a horizontal iron frame (A), resting upon three small standards or feet. Above and immediately under the gun is a fixed platform (B), supported by the iron tripod, CCC. This platform limits the travel of the recoiling portion of the rest, and also carries the scale (K) by which the recoil is measured. D is the recoiling platform, to which the gun is attached, at E, by a universal joint. At F the barrels of the gun are supported in a V-shaped notch or groove; and the barrels are held in position by a strong india-rubber band shown in front of the groove. The elasticity of this band allows the gun, on being fired, to behave in the same manner as if it were fired from the shoulder. The recoiling platform (D) is supported at opposite ends by the parallel motion, LL, moving on centres at the top and bottom of the rods.

H is a spring balance, connected with the parallel motion by the toggle-joint I. The toggle-joint is an important feature in this gun-rest, as the varying strength of the spring is equalised by its means, and the gun therefore recoils against a constant amount of resistance.

J represents an oil reservoir, containing a cylinder and piston which automatically bring the gun slowly back to the firing position after it has been discharged; and for ordinary target work this arrangement is very convenient. For experimental purposes, however, when it is desired to ascertain the recoil with great exactness, the oil reservoir may be detached and a ratchet and pawl substituted;

though, of course, their use gives some little additional trouble. This ratchet is always used in our own experiments.

K is the marker, which records on the scale the extent of recoil, as measured in inches, and tenths and hundredths of an inch.

Under ordinary conditions of use, the machine stands on the ground in the position shown in the illustration, and the gun is fired in a horizontal direction. For the purpose, however, of ascertaining definitely what the work performed in the recoil movement actually amounts to, a number of experiments were also carried out with the machine suspended vertically a few yards above ground, and the gun was fired with the muzzle pointing downwards. In such case the recoil movements must necessarily take an upward direction, and (the spring, H, having been temporarily detached) the gun, in recoiling, had to lift up its own weight, together with the operative weight of the movable portion of the machine. The space through which this combined weight was raised was registered on the scale of the machine; and from these data, of weight lifted and height of lift, the amount of work done can be readily calculated.

Under such circumstances, the process of loading and firing the gun, and taking the records, becomes exceedingly slow and tedious. But these vertical experiments were carried out merely for the purpose of ascertaining whether the apparatus would work with a fair amount of accuracy in the horizontal position, when the resistance of a spring had to be used as a substitute for the vertical force of gravitation. The acting weight of the movable portion of the machine (as ascertained by the amount of "draw" on a spring balance) was nearly 27lb., and thus, with a 7lb. gun, the full weight to be lifted would be about 34lb. For facility of calculation, however, we had the total weight made up to exactly 35lb. (or five times the weight of a 7lb. gun), by screwing on to the machine sufficient sheet lead to make up the defidency. And the strength of the spring, when used to resist the horizontal recoil, was likewise set at 35lb. But the spring can be regulated to different degrees of strength, according as the weight of the gun or other circumstances may render desirable.

A comparative trial of four well-known powders was accordingly carried out by these two methods—three rounds being fired with the vertical lift, against the force of gravity, and three rounds with the horizontal recoil against the action of the spring; and the results will be seen in the following table, which shows, in inches and decimal parts, the space through which the 35lb. weight was moved. The charge used was 3drs. of black powder, or 42grs. of nitro, with a spherical ball weighing 525grs., or a charge of shot of equal weight; wads and cases being alike throughout.

Powders.	Vertical Lift.				Horizontal Recoil.			
	Inches.			Averages.	Inches.			Averages.
No. 2 Black:								
With Bullet	2·60	2·59	2·52	= 2·57	2·50	2·47	2·50	= 2·49
„ No. 2 shot	2·48	2·47	2·47	= 2·47	2·48	2·46	2·40	= 2·45
„ No. 8 shot	2·36	2·30	2·32	= 2·33	2·40	2·45	2·40	= 2·42
	General average			2·46	General average			2·45
No. 4 Black:								
With Bullet	2·27	2·25	2·26	= 2·26	2·30	2·28	2·27	= 2·28
„ No. 2 shot	2·36	2·33	2·26	= 2·32	2·32	2·33	2·33	= 2·33
„ No. 8 shot	2·32	2·31	2·30	= 2·31	2·30	2·35	2·35	= 2·33
	General average			2·30	General average			2·31
No. 6 Black:								
With Bullet	2·05	2·00	2·00	= 2·02	1·96	1·96	1·97	= 1·97
„ No. 2 shot	1·97	1·96	1·96	= 1·96	2·03	1·98	1·97	= 1·99
„ No. 8 shot	1·87	1·90	1·90	= 1·89	1·98	2·00	2·00	= 1·99
	General average			1·96	General average			1·98
Schultze:								
With Bullet	1·61	1·78	1·77	= 1·72	1·62	1·65	1·60	= 1·62
„ No. 2 shot	1·90	1·85	1·79	= 1·85	1·87	1·90	1·93	= 1·90
„ No. 8 shot	1·75	1·80	1·72	= 1·76	1·92	1·90	1·88	= 1·90
	General average			1·78	General average			1·81

Considering that successive charges, fired under exactly the same conditions, seldom give exactly the same results, either as regards the velocity of the shot or the recoil of the gun (owing probably to difference in strength of the caps), these averages appeared to be close enough to warrant us in assuming that the horizontal recoil against the spring resistance gives results sufficiently near to the vertical lift against the action of gravity, to meet the purposes we required.

We subsequently tried another set of experiments, with respect to the vertical lift, by detaching the gun entirely from the machine, and suspending it, muzzle downwards, alongside a scale marked upon a whitened surface; and, on the gun being fired, a pencil attached thereto marked a line by the scale, showing the height to which the gun had been lifted. This was found to be between four and five feet, according to the nature of the charge; and on multiplying the weight of the gun (7lb.) by the height of the lift, the number of foot-pounds was ascertained. The results thus obtained with the gun alone corresponded with those recorded when the gun was attached to the machine. Thus, in the one instance, 35 pounds were moved horizontally against the force of a spring; and, in the other, the 7lb. gun was raised to a height of 5 feet against the force of gravity.

So far as our experiments have yet gone, they appear to show that the actual amount of recoil exhibited by small arms is considerably greater than that estimated from the formulæ ordinarily found in military text-books. This we attribute to the fact that such formulæ only take into consideration the weight and velocity of the body projected, and disregard any additional work that may be done in the interval between the ignition of the powder and the clearing out of the powder gases. That a considerable amount of work must be done during this interval appears obvious, when we take into consideration the frictional resistance of the shot and the force employed in expelling the column of compressed air in front of the projectile. But in big guns these items probably form much less important factors than in small arms, because the amount of air-resistance (*per square inch*) in front of a bullet or shot-charge weighing an ounce or less may be as great as in front of a projectile weighing about a ton, whereas the pressure per square inch *behind* the projectile is trifling in the sporting gun as compared with that in large ordnance.

At all events, it would seem that the amount of recoil exhibited by a gun bears no fixed relation to the weight and velocity of the projectile; but that it varies with the kind of powder and shot used, and some other conditions. There may be a certain amount of recoil, with a definite muzzle velocity, on firing a spherical ball from a smooth-bore with 3drs. of powder; and on firing a similar charge of powder, from the same gun, with a charge of small shot of the same weight as the bullet, the increased friction in the barrel may greatly reduce the muzzle velocity of the shot yet leave the recoil very little altered, or occasionally the recoil may even show an increase, as in some of the instances here recorded. Again, when a barrel is foul, the velocity of the projectile is greatly diminished: but the amount of recoil is not diminished in the same ratio. Thus, the doctrine that "action and reaction are equal and opposite" does not appear to work satisfactorily when taken in the restricted sense in which it has often been applied in the formulæ of military text-books.

If action and reaction can be relied upon for estimating the recoil of the gun from the muzzle velocity of the shot, it should likewise be applicable to the converse process of estimating muzzle velocity from the amount of recoil. But, on adopting such a course, we find that the estimated muzzle velocity stands hundreds of feet higher than the actual speed which the chronograph records. We therefore conclude that the speed of the projectile merely indicates the *effective work* performed by the powder in imparting energy to the shot; whereas recoil is a representation of the total work performed in the gun—that is to say, it includes the *non-effective work* performed in overcoming frictional and other resistances, as well as the energy transferred to the projectile; and in some instances the non-effective portion appears to be the larger of the two.

T.

THE "FIELD" SYSTEM OF LOADING.

Frequent allusion has been made to the "Field" wads and method of loading introduced by Mr. Walsh; and we therefore reproduce detailed particulars, published in 1878:

Directions for Loading 12-Bore Cartridge Cases either with Black or Schultze Powder.

Obtain three kinds and sizes of wadding, which are now made by Messrs. Eley, and may be obtained by all gunmakers:

1. A thick wad of fine felt, pink on one side and grease-proof black on the other, 11¼ to 11½ gauge (subsequently 11¾ gauge was considered sufficient); edge slightly greased.

2. A greased felt wad, carefully cut to 11½ gauge, and ⅝ to half an inch in length.

3. A thin cardboard wad, 12-gauge, so as to just fit the case.

First pour in the powder, then introduce the wad No. 1, with the black side downwards; put on this the felt wad No. 2, and gently seat them together or separately, using no more pressure than is needful for that purpose. A wad No. 3 is then dropped down, the shot poured in, and another of the No. 3 wads placed over it. The third wad over the felt may be dispensed with if so desired, but it certainly increases the regularity of the pattern.

The cases are now ready for turning down, on which we have no remarks to make, except that with the Schultze powder it is necessary that it should be fully done, in order to increase the initial pressure.

The following remarks (extracted from the *Field* of Dec. 28, 1878) will afford an explanation of the reason why the tight pink wad and thick felt, prescribed in the above directions for loading, so greatly

improve the shooting of guns in which paper cases are used. In guns that are specially made for the thin brass "Perfect" cases, which have since been brought out, the cone is practically *nil*.

"Our attention has been drawn by Mr. Mirfin to a simple experiment, which probably shows the reason why a tighter wad than usual improves the shooting of most guns. The screw of a cleaning rod is first driven into a pink wad; and the latter is inserted in the mouth of a cartridge case so as to be exactly level with the edge. In this condition the two are placed in the chamber of a gun, which is then closed, leaving the rod projecting from the muzzle. A mark is then placed on the rod, level with the muzzle, and it is carefully raised by the fingers. As soon as the wad leaves the case, the rod will be felt to jump, till it is brought up by the wad entering the commencement of the true barrel. In the interval the wad has been loose in the cone, and will allow the gas resulting from the explosion of the powder to pass by its side under certain circumstances, to be presently considered. We find by thus experimenting on the guns of various makers, that this cone measures from one quarter of an inch to three-quarters; half an inch being the usual length in most guns recently built by the best makers. Now, it is clear that if the wad or wads over the powder are not long enough to reach from the mouth of the case to the entrance of the barrel—that is to say, to bridge over this chasm—an escape of gas into the shot will take place, and there will be the wild shooting which formerly was the rule with almost all guns.

"We append a rough diagram, which shows the two conditions sufficiently clearly for our purpose. Fig. 1 indicates our two wads at the moment of leaving the case in a cone of the average length. Here it will be seen that, before the thinner tight wad has left the case, the felt has reached the barrel (A B), and little or no gas escapes. In Fig. 2, however, the single wad does not extend to the foremost

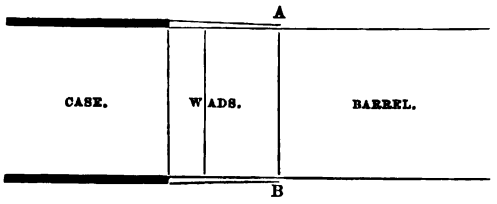


Fig. 1.

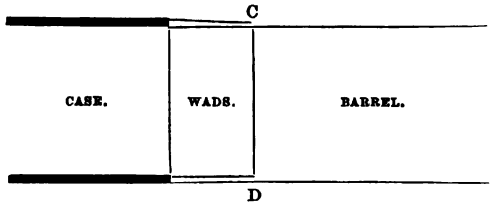


Fig. 2.

shoulder of the cone (C D); and before it reaches the barrel it has allowed the gas to escape.

"By trying this simple experiment, the proper length of felt wad can always be adopted. All that is necessary is to measure the length of the cone by the above method, and then select a felt wad of such a length as, with the pink one, will be equal to that of the cone.

"It is, in our opinion, owing to this cause that the tight pink wad improves the shooting of black powder; but in the case of Schultze powder, it not only acts beneficially in the same way, but gives the increased initial pressure which is necessary for the proper development of gas from that powder. This is also the reason why our plan fails altogether unless the cartridge case is of a length suited to the chamber. Most pigeon guns are now chambered to take a 2⅝in. case, or even a longer one; and if they are used with a 2½in. case, there is an eighth of an inch not provided for, the gas escapes, and wild as well as weak shooting results."

[Since the foregoing particulars relative to *Field* wads and methods of loading were published, we have found it desirable to make a change, as, in our opinion, many of the so-called *Field* wads that have of late been thrown upon the market are much inferior in quality to those which were originally made. We have therefore discontinued the use of the black-and-pink wads, and now use the best grey cloth wads, as giving more regular results. Our present method of loading is as follows: First, a card upon the powder, then a ⅜-inch soft felt, next a grey cloth wad, followed by the shot, and a thin card over the shot, finishing by a turn-over of a quarter of an inch. If the charge is such that the turn-over would be more or less than a quarter of an inch, the card over the powder may be thicker, or two cards may be used, or *vice versâ*, so as to give the proper amount of turn-over. This is especially requisite with nitro powders, some of which would do better with rather more than a quarter of an inch of turn-over.]

HOW A GUN WAS BURST.

(*Field*, March 10, 1888; Vol. 71, p. 333.)

SIR,—The following account of the bursting of a gun may be of interest to some readers of the *Field*. The gun, a muzzle-loader, was loaded with, first, a little black powder to fill the nipples and assist ignition; then the bulk of Schultze powder, that would have been 3½drs. of black; above that a cardboard wad; then 1¼oz. of No. 8 shot, with another cardboard over all. The result was that the breech of the gun and the lock were blown into fragments; the man who fired it had his middle finger blown off (curious enough, he lost his thumb and forefinger by a similar accident twenty-six years ago), and a piece of metal went through the thigh of one of the bystanders.

The questions which present themselves to one's mind are: First, is it safe to use nitro-compounds in muzzle-loading guns? Secondly, would the priming of black powder have any injurious effect on the Schultze? Thirdly, was the gun too heavily loaded? ENQUIRER.

[We have again and again, for years past, warned our readers against the dangerous practice of using black powder as a priming, to make the nitro-compounds ignite more rapidly. They are not intended to ignite more rapidly; and this interference with the normal condition of the powder quite alters the character of the explosion. Some of the accidents on which we reported about four years ago were produced in this way; and the experiments carried out by the late Mr. Walsh showed how greatly the strain on the barrel was increased by the rapidity of the explosion. In the present instance everything was different from what it should have been. Besides the black powder, there was probably about 50grs. of Schultze, with 1¼oz. of No. 8 shot, the resistance of which in the barrel is much greater than larger-sized pellets; and, from its being a muzzle-loader, the probability is that the gun was an old one. In fact, everything seemed planned for a burst.—ED.]

EFFECTS OF PROJECTILES ON LIVING BODIES.

(*Field*, April 14, 1894; Vol. 83, p. 516.)

THE destructive effects of projectiles on the human body were the subject of a lecture by Professor V. Horsley at the Royal Institution on Friday, April 6. The effect of the "wind" of a small projectile was altogether ignored, as was the influence of the rotation of a rifle bullet, and that of the heat of the bullet, which had been greatly exaggerated. The speed of the projectile was regarded as an important factor in the effects produced, and also its sectional area and weight; but Professor Horsley regarded the constitution of the body struck as having the most important bearing on the behaviour of the bullet striking it. He asks, Why does a bullet simply perforate some substances such as wood or iron, while in others, such as clay, brain, &c., it exercises a bursting action? The answer, he says, is quite simple; the destructive effects vary directly as the viscosity of the body. This was established by some remarkable researches made by Huguier, who suggested, from observations on dead organs, that the cause of the great disturbance was when the tissues contained water in large quantity, and that the energy of the projectile being imparted to the particles of water caused their dispersion. This suggestion was shown to be correct by Kocher. If a shot be fired through two tin canisters of equal size, the one full of dry lint and the other of wet, it will simply perforate the former, but cause the latter to burst explosively. In the same way, shots fired into dough have more or less disruptive effect, according to the amount of water in the dough; the more fluid the substance the greater the destruction. Now, in life the brain is a more or less fluid body; hence a shot fired into the skull must have a disruptive effect, and the brain substance must be driven against the internal surface of the skull. Professor Horsley then passed to the pathological side of the subject, and described the experiments by means of which he verified the deductions. The experiments show that the first cause of death in such cases is not arrest of the heart, and syncope, as the text-books affirm, seeing that the heart continues to beat. It is rather arrest of breathing; and, if artificial respiration be quickly performed, recovery from the otherwise fatal arrest may be obtained, as has been experimentally proved. The practical deduction from this fact is that, with wounds in the head from rifles and revolvers, the first thing to be done is to employ artificial respiration rather than to give stimulants, as is not unfrequently done, especially by non-professional persons who witness accidents arising from gunshot wounds.

TRIAL OF 12, 16, AND 20-BORE GUNS.

(*"Field," March* 14, 1896; *Vol.* 87, *p.* 376.)

EARLIER IN THE CENTURY the sportsman had more variety in the gauges of his guns (nominally, at all events) than he has at present. Then it was common enough for a man to swear by his 13, or 15, or 17, or some other pet bore, as decidedly the best for all-round purposes. But lightness was not then so much in demand as it is nowadays; as witness the following remarks of Colonel Hawker, in his edition of 1826, page 21:

In choosing the size of a caliber, it may be considered that a 14-gauge is at all events the best for a bungler, and, on the whole, the most destructive gun. But, with a very accurate shot, the size is not of so much consequence for killing game; as the necessary substance to prevent the recoil of a large bore cannot be brought to bear so quick as a somewhat lighter gun; and, therefore, what is gained by weight of metal might be lost in time. Supposing, however, that weight is not objected to, the gun to be recommended is a 14-gauge, and, if a double one, of about 9 pounds, after the beginning of October, till which time a 22 gauge gun will do equally well, and be lighter to carry during the warm weather. (Remember, I am now speaking of a flint-gun, as a light small-bore percussion gun is, I conceive, incompatible with safety.)

And then, again, as regards the proportion of length to gauge, what would modern sportsmen think of adopting the opinions given on page 15?

It was formerly the custom to make barrels, although so small as 14, 16, or even 22 in the gauge, of three or four feet in length; and now, since it has been ascertained that 2ft. 6in. will shoot equal well, at the short distance of a gunmaker's confined premises, many have gone too much to the other extreme, and cut them to 2ft. 4in., and less. The disadvantage of this is, that even the best shots are more liable to miss; as, although we allow that a short gun, at a short distance, will kill as well as a long one, yet the latter gives you a more accurate aim, and considerably lessens the recoil, by which you shoot to a greater nicety, and with more steadiness. To avoid all extremes, I should recommend small barrels, never less than 2ft. 6in., nor more than 3ft. in length. My readers will observe that my remarks here have been altered since publishing my earlier editions. Mr Joseph Manton, who knows, at all events, as much as, if not more than, any man in Europe about a gun, declared to me, very lately, that after innumerable experiments, he has proved that 2ft. 6in. for a 22-gauge barrel is the best proportion for a sporting gun. Take, therefore, a 14-gauge barrel, and see whether or not I am right for recommending one of 2ft. 10in., and 3ft. where it can be used without inconvenience.

Some thirty years later, in 1858, when the first of the *Field* gun trials was held, for the purpose of gaining some definite information as to the relative merits of breechloaders and muzzle-loaders, the variations in bores and weights of guns were still very different from what they now are. There were muzzle-loaders with 31in. barrels; a 12-bore breechloader weighing 7lb. 12oz.; 14-bore breechloaders weighing 7lb. 8oz., 7lb. 7½oz., and 7lb. 6oz., respectively; besides other breechloaders of 13 and 15 bore. As time went on, however, owing to the inconveniences arising from multiplicity of cartridges, the intervening gauges were abandoned and cartridges became generally restricted to 12, 16, 20, and so on. Nevertheless, in other respects there are probably more variations at present than there were in the old days, for most of the so-called 12-bores are now choked to 13 or 14, or some smaller gauge, in one if not both barrels; and other guns are made for use with thin brass cases, the internal gauge of which is larger than the number borne upon the outside of the shell. Hence many of the so-called 28-bores are really of 24-gauge, and are used with the wads and charges appropriate to that bore.

In former times, when all charges had to be put in at the muzzle, the wads necessarily were limited to such a size as could be driven down by the ramrod—unless, indeed, a piece of crumpled-up paper, or other flexible material, were used instead of the punched card. Now, however, that they are inserted at the breech, and, instead of being pushed by the force of the ramrod, there is a gas-pressure of several tons per square inch to drive them forward, the 12-bore wads that are put in the cartridge emerge at the opposite end of the barrel with their dimensions reduced to 13, 14, or some even to 20 gauge.

We have no example of such extremes in our present trial. We received, however, one gun which had been bored for the thin brass cases; and, not being aware of the fact, we began to test it with the same paper cases and wads as were being used for the other guns; but the records were so bad that we saw there was something wrong; and, finding that the gun required to be used with larger wads and different cases from those adopted for the rest, we were obliged to return this gun to its owner untried.

The guns included in the present trial are all under 6lb. in weight, whether of 12, 16, or 20 gauge, and the lightest of the whole series is a 12-bore, weighing 4lb. 14oz. Each gun, whatever its weight or bore, is tried with two charges of No. 6 shot, viz., 1oz. and ⅞oz.

In order to obtain a datum line which shall be common to the whole of the guns, we first tried a 12-bore with 3drs. of No. 4 black powder and 1⅛oz. of No. 6 shot, and found that, in a dozen rounds, it gave a mean velocity of 1160 feet per second in a 10 yards range. This is equivalent to a muzzle velocity of rather over 1200 ft.sec., and also to about 880 f.s. mean velocity for 40 yards. We thought it desirable to have the chronographic velocity for a short range only, as there would probably be less variation of speed than would result in a range of 40 yards, where the charge is so much more scattered; and thus there would be better means of comparison. For the general trial, all the cartridges were loaded with the same nitro powder, and in order to bring up every gun to the datum line of velocity, each one was first tried separately, and the charge of powder increased or decreased until it gave as nearly as possible an average of 1160 f.s. It has been said that, by thus using charges which perhaps were different from those ordinarily used in the respective guns, each might not have an opportunity of doing its very best. That may possibly be true; but one cannot compare incomparables; and the prime object of this trial is not to ascertain whether Mr A.'s gun, with his favourite charge, will shoot better than Mr B.'s and Mr C.'s with their favourite charges, but rather to ascertain what are the general results which ensue when a number of light 12-bores, a number of 16-bores, and a number of 20-bores are used under as nearly as possible the same conditions as regards the weight of the shot charge, and the velocity imparted to the pellets. Then one may also be able to come to a conclusion as to which bore and length of barrel generally give the best average results as to pattern at 20, 30, and 40 yards; what weight gives the most satisfactory amount of recoil; and what is the relative amount of gas pressure in the respective bores. And, in order that no disparagement may be given to any particular gun or guns by the variety or charge of powder, weight or size of shot, and kind of cartridges employed, being different from those ordinarily used by the owners of the guns, we indicate them only by their bores and the numbers on the barrels. This will enable the owners to recognise their own weapons, and each will be able to form his own opinion as to whether the charge used in the trial gives better or worse results than ordinary.

Some Remarks on "Killing Circles."

As all circles are proportionate to one another, in like manner as all squares are proportionate, comparisons may be greatly facilitated if one regards a large circle as equal to an aggregate of small circles, in the same way as a large square is equal in area to a number of small squares.

Nearly everyone knows that a 10 inch square covers a space of 100 square inches, and that a square foot contains 144 square inches; whereas comparatively few people know the area of circles that are 10 inches or 1 foot in diameter; and when told that the 10 inch circle is equal in area to 78·54 square inches, and that a circle of 1 foot in diameter corresponds with a fraction over 113 sq. in., the information may not seem particularly easy of application to other purposes. When, however, circles of given diameter are dealt with in a similar way to squares, comparison is rendered easy, and conversion into square inches may be dispensed with.

For example, if a 30in. circle is regarded as 900 circular inches (instead of about 706½ square inches), the number 900 may be readily manipulated in various ways. Thus, 1¼oz. of No. 6 shot contains, in round numbers, 300 pellets; and consequently, if the whole of the charge were placed within the 30in. circle, each pellet would, on the average, occupy the space of three circular inches. But the most constricted chokebores would not be likely to perform that feat at a distance of 40 yards; though some might do so at 30 yards. Keeping, however, to the 40 yards distance, full-choked 12-bores not unfrequently put 220 or 230 pellets in the 30in. circle; and an average proportion of 4 circular inches of space to every pellet would be equivalent to a pattern of 225. A medium choke, with 180 pattern, averages 5 c.in. per pellet. A slight choke, of 150 pattern, equals 6 c.in. A very good cylinder gun, that gives close on 130 pattern, has an average of 7 c.in. per pellet; and a rather poor cylinder, with 112 pattern, would average 8 c.in. So that a definite idea may thus be formed of the relative amount of space covered by charges of shot when fired from guns that are more or less choked, or not choked at all.

Again, supposing that, instead of 1¼oz. of shot being the charge adopted, only 1oz. or ⅞oz. were used, then, if the distribution of pellets were in the same proportion as before, the killing circle would necessarily be reduced in correspondence with the lessening of the shot-charge; and where 1¼oz. would cover 900 circular inches, 1oz. would cover 800 c.in., ⅞oz. would be equivalent to 700 c.in., and so on.

It need hardly be said, however, that such precision could only occur with *ideal* patterns, where pellets are distributed with the utmost regularity throughout the entire body of the shot-charge. And one of the purposes of the present series of experiments is to ascertain how nearly the actual performances of guns compare with the ideal results which are based merely upon arithmetical proportions. But it may be taken for granted that the nearer the practical results approach to the ideal regularity, the greater is the reliance which may be placed upon the shooting of the gun; for nothing can be more vexatious than to have pellets in one part of the pattern so closely "bunched" together that the game brought to bag appears to be "stuffed with lead," whereas elsewhere the charge is so unevenly scattered that birds within what ought to be the "killing circle" are able to continue their flight unscathed.

In order that the results of our experiments may be compared with more precision than heretofore, we have divided the target by concentric rings—not of equal distances apart, but so placed that the intervening bands may be equal in area to one another. The first circle has a diameter of 15in., and consequently its area is one-fourth that of the 30in. circle; or, in other words, contains 225 c.in. The diameter of the second circle is 21¼in., and the area of the belt between the 15in. and 21¼in. circles is also equal to 225 c.in. So, likewise, the belt between 21¼in. and 26in., and that between 26in. and 30in., have the same equal area of 225 c.in. And the acme of perfection in the distribution of the charge would be for exactly the same number of pellets to be equally distributed in each of the four divisions of the target.

Of course, upon the closeness and regularity of the pattern generally will depend the number of pellets within the respective circles, and the number of supplementary circles over which the charge of shot may happen to be distributed. Supposing, for instance, the gun to be but slightly choked, and to average about 150 pellets in the 30in. circle at 40 yards. There would be a similar number of pellets outside the 30in. circle; and so the charge, if evenly distributed, would extend over four more concentric rings, each of equal area with its predecessors. Thus, the whole space covered would amount to 1800 c.in., and the diameter of the killing circle would be as the square root of 1800, or between 42 and 43 inches in diameter, in a 40 yards range. At half that distance, the killing circle would have about half that diameter; at three-fourths the distance it would have about three-fourths the diameter, and in similar approximate proportion for other distances.

On the other hand, if there be found within the first ring about double as many pellets as there are, say, between the third and fourth, it will be obvious that the charge is not evenly distributed, the two areas being of equal dimensions; and the probability therefore will be that the farther the pellets are from the centre of the circle the wider will the gaps between them be; and consequently, although there may be a circle of pellets, it may be anything but a "killing circle."

In our opinion, the "killing circle" of a gun cannot possibly be said to extend beyond that point where the pellets are more than 4in. apart on the average; or, in other words, where there are fewer than, say, 15 pellets in one of the above-mentioned belts. In such case there would be 15 circ. inches of space to each pellet, which is equivalent to a pattern of only 60 in the 30in. circle, supposing the pellets to be quite evenly distributed. No doubt many people would say that 4in. would be too wide apart; and that it would suffice to estimate the pellets at 3in. apart, which would allow 9 circ. inches to each pellet, and would thus be equivalent to 100 pellets in the 30in. circle, if evenly distributed. And we should be inclined to agree with them; for if one pellet struck a partridge in the body, and the next pellet were 4in. distant, there would be little probability of the bird being hit by two pellets. Nevertheless we will state the killing circle on the more liberal basis; and if anyone considers the width too excessive, he can readily reduce the estimate by taking off one ring, thereby lessening the stated diameter of the circle by about 3in.

The Size of the Rings.

The diameter of the 1st ring is 15 inches; area, 225 circular inches.

" " 2nd " 21¼ "
" " 3rd " 25 "
" " 4th " 30 "
" " 5th " 33½ "
" " 5th " 36¾ "

} The area of each belt, between two rings, is the same above.

As it is usual to designate patterns by the number of pellets in the 30in. circle, we state them separately in the tables, and likewise the number of pellets outside the 30in. circle; so that anyone interested may compare, and see what proportion are scattered beyond the circumference of the 6th ring.

12-BORE, No. 5446; weight, 5lb. 13½oz.; barrels, 28in.

RIGHT BARREL, 38grs. powder, 1oz. of shot (270 pellets); gas pressure 1·38 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	31	30	27	27	22	27	115	155	1145	26·9
2	43	35	29	22	18	14	129	141	1158	27·2
3	40	31	36	20	15	9	127	143	1128	26·7
4	28	27	31	29	20	25	115	155	1149	27·8
5	41	33	24	26	18	16	124	146	1145	27·0
6	50	40	29	21	26	8	140	130	1132	26·7
7	22	25	25	23	29	23	95	175	1167	27·3
8	37	28	28	26	20	27	119	151	1154	27·4
9	45	41	22	25	19	13	133	137	1172	27·8
10	35	38	29	34	27	14	136	134	1172	27·9
Aver....	37	33	28	25	21	18	123	147	1153	27·3

80 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	71	58	29	34	18	18	192	78		
2	35	44	40	37	22	11	156	114		
3	67	50	29	29	24	10	175	95		
4	76	48	30	28	21	12	182	88		
5	28	24	39	32	20	19	123	147		
6	66	56	21	25	15	16	168	102	(As above.)	
7	72	49	33	30	19	11	154	116		
8	58	42	35	30	23	17	165	105		
9	70	53	33	27	21	17	183	87		
10	37	57	50	23	13	13	166	104		
Aver...	58	48	34	29	20	14	169	10[illegible]		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	144	70	22	14	7	2	250	20		
2	129	55	31	24	11	3	239	31		
3	98	61	41	21	5	7	223	47		
4	72	59	43	43	14	6	216	54		
5	116	68	30	15	12	5	229	41		
6	88	50	23	17	7	5	178	92	(As above.)	
7	102	47	37	23	8	2	209	61		
8	117	43	41	18	11	5	219	51		
9	111	53	38	23	8	8	223	47		
10	110	60	39	26	9	9	235	35		
Aver.	109	56	34	23	9		231	49		

LEFT BARREL, 38grs. powder; gas pressure, 1·38 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards.) Ft.sec.	Recoil. Ft.lb.
1	40	29	18	20	18	21	107	163	1136	27·3
2	46	25	20	14	12	18	105	165	1163	27·7
3	35	36	28	23	19	15	122	148	1176	28·0
4	39	28	21	13	18	9	101	169	1154	27·5
5	46	37	23	15	11	10	121	149	1176	28·3
6	30	27	30	23	20	17	110	160	1158	27·3
7	35	33	29	18	18	14	115	155	1172	28·0
8	41	36	19	21	26	19	117	153	1190	29·0
9	47	32	24	27	15	10	128	142	1145	27·0
10	31	38	28	26	23	20	126	147	1141	27·2
Aver.	39	32	24	20	17	15	115	155	1161	27·7

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	70	61	47	29	21	16	207	63		
2	86	51	23	31	24	10	191	79		
3	81	48	38	30	17	14	197	73		
4	68	54	37	29	25	23	188	82		
5	79	56	21	19	19	22	175	95		
6	90	57	29	18	15	11	194	76	(As above.)	
7	69	53	45	24	24	20	190	80		
8	73	55	39	31	27	19	198	72		
9	83	53	30	21	19	15	187	83		
10	67	56	37	33	23	17	198	77		
Aver.	77	54	35	26	21	17	192	78		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	71	44	36	26	16	5	177	98		
2	133	54	37	20	11	3	243	27		
3	89	57	39	25	15	5	210	60		
4	111	60	31	19	14	8	221	49		
5	127	61	29	21	18	3	238	32		
6	95	70	30	27	11	8	222	48	(As above.)	
7	123	68	26	16	14	7	238	37		
8	70	66	39	23	10	4	198	72		
9	117	61	28	18	15	6	234	46		
10	46	57	49	43	19	7	195	75		
Aver.	98	60	34	24	14	6	216	54		

12-BORE, No. 5446; weight, 5lb. 13½oz.; barrels, 28in.

WITH SMALLER CHARGE OF SHOT.

RIGHT BARREL, 37grs. powder; ⅞oz. of shot (236 pellets); gas pressure, 1·23 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards.) Ft.sec.	Recoil. Ft.lb.
1	23	30	24	20	14	13	97	139	1167	23·9
2	40	28	18	15	13	15	101	135	1158	23·0
3	27	25	33	23	10	11	107	129	1145	21·8
4	24	31	26	21	12	8	102	134	1158	24·0
5	35	32	21	19	8	16	107	129	1136	23·3
6	44	26	26	14	6	9	110	126	1149	23·0
7	41	29	20	12	11	7	102	134	1172	22·7
8	30	37	29	17	12	14	113	123	1132	21·0
9	37	37	30	20	13	10	124	112	1167	23·1
10	29	31	23	18	16	11	100	136	1141	21·6
Aver.	33	34	25	18	11	11	110	126	1152	22·5

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	45	47	29	26	19	10	147	89		
2	79	41	31	26	18	6	177	59		
3	43	49	26	27	17	11	144	92		
4	69	35	22	16	16	12	142	94		
5	77	38	32	18	15	9	165	71		
6	61	40	25	22	12	8	148	88	(As above.)	
7	43	50	31	20	21	14	144	92		
8	58	45	29	19	10	15	151	85		
9	70	47	33	33	11	5	183	53		
10	55	58	27	23	14	10	163	73		
Aver.	60	45	28	23	15	10	156	80		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	84	54	28	17	9	3	183	53		
2	88	47	22	23	5	7	180	56		
3	101	48	31	17	11	2	197	39		
4	53	59	42	21	17	4	175	61		
5	108	41	20	15	11	3	184	52		
6	90	39	29	27	7	2	185	51	(As above.)	
7	89	56	38	17	13	5	200	36		
8	61	44	48	24	16	6	177	59		
9	121	53	19	12	3	5	204	32		
10	96	57	30	19	13	4	202	34		
Aver.	89	50	31	19	10	4	189	47		

LEFT BARREL, 37grs. powder; gas pressure, 1·23 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yds.) Ft.sec.	Recoil. Ft.lb.
1	20	19	26	15	23	24	80	156	1158	23·0
2	33	33	22	18	17	21	105	131	1149	22·7
3	35	27	25	22	21	18	109	127	1172	23·6
4	29	36	34	27	25	18	128	110	1136	19·8
5	36	32	25	26	23	10	119	117	1136	21·6
6	24	25	31	17	20	12	97	139	1167	23·0
7	27	30	20	18	18	20	95	141	1141	20·9
8	41	24	19	16	15	14	100	138	1163	22·0
9	31	33	33	29	26	27	126	110	1154	19·9
10	39	26	28	23	19	19	116	120	1168	20·4
Aver.	31	28	26	21	21	18	106	130	1154	21·7

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	49	37	23	18	8	10	127	109		
2	58	49	27	29	16	11	163	73		
3	25	24	22	20	19	13	91	145		
4	39	41	38	22	14	17	140	96		
5	61	37	26	30	16	12	154	82		
6	37	48	33	31	22	15	149	87	(As above.)	
7	56	49	21	23	13	11	142	94		
8	60	35	32	27	15	15	154	82		
9	53	44	28	25	17	9	150	86		
10	49	48	29	19	20	14	145	91		
Aver.	49	40	28	24	16	13	141	95		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	107	55	25	12	7	6	199	37		
2	87	56	35	25	11	9	153	83		
3	80	49	22	19	5	4	170	66		
4	86	55	38	27	8	7	206	30		
5	91	39	24	13	8	8	167	69		
6	79	52	23	14	14	1	168	68	(As before.)	
7	103	50	27	16	7	2	196	40		
8	42	51	34	20	9	11	147	89		
9	113	31	26	12	4	3	189	54		
10	96	35	33	19	5	2	188	58		
Aver.	83	47	29	18	7	5	177	59		

("*Field*," *March* 21, 1896; *Vol.* 87, *p.* 376.)

LAST WEEK we published the first instalment of the records obtained in the present trial; and now we propose to make a few comments thereon, as they probably may have some bearing upon results which are yet to come.

The gun tried was a 12-bore, with 28 inch barrels, and weighing 5lb. 13½oz. With 38grs. of nitro powder and 1oz. of shot, the right barrel gave an average pattern of 123 pellets in the 30 inch circle at 40 yards, and a velocity of 1152 feet per second. (This velocity, as explained last week, was the mean velocity of the first 10 yards from the muzzle of the gun.) The left barrel gave a pattern of 115, with a velocity of 1161 f.s. It will thus be seen that there is very little choke in this gun, and what little there is occurs in the right barrel, as the owner of the gun is in the habit of firing the left barrel first.

With the smaller charge, of ⅞oz. shot, 37grs. of powder were used. The pattern of the right barrel averaged 110, and the velocity 1152 f.s.; while with the left barrel the average pattern was 106, and the velocity 1154 f.s. There were fluctuations, however, from round to round with both charges; and as similar fluctuations are likely to occur with all guns, we take the records of No. 5446 12-bore as a text whereon to base some remarks having a more general application. In the first place we will allude to the

RECORDS OF VELOCITY AND RECOIL.

1oz. Charge of Shot.				⅞oz. Charge of Shot.			
Right Barrel.		Left Barrel.		Right Barrel.		Left Barrel.	
Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.
1172	27·9	1190	29·0	1172	23·7	1172	23·6
1172	27·8	1176	28·3	1167	23·9	1167	23·0
1167	27·3	1176	28·0	1167	23·1	1163	22·0
1158	27·2	1172	28·0	1158	24·0	1163	20·4
1154	27·4	1163	27·7	1158	22·0	1158	23·0
1149	27·8	1158	27·3	1149	23·0	1154	19·9
1145	27·0	1154	27·5	1145	21·8	1149	22·7
1145	26·9	1145	27·0	1141	21·6	1141	20·9
1132	25·7	1141	27·2	1136	22·3	1136	21·6
1128	26·7	1136	27·3	1132	21·0	1136	19·8
1152 Aver.	27·3	1161 Aver.	27·7	1152 Aver.	22·5	1154 Aver.	21·7

Here it will be seen that, instead of following the order in which the rounds were fired, as given last week, we have arranged the records in order of velocity; and it will also be observed that in most instances the highest velocity is accompanied by the greatest amount of recoil; though such is not always the case. It may not unnaturally be asked—Why should a succession of cartridges out of the same batch give different velocities? and why should similar velocities be occasionally accompanied by different amounts of recoil?

Perhaps the reply given by most people to the first part of the inquiry would be, that there may have been some little difference in the quantity of powder put in the cartridges. Personally, however, we do not consider it at all likely that such an answer could be correct in this instance, whatever might be the case under ordinary circumstances.

Care Taken in Loading the Cartridges.

In these cartridges, specially loaded for purposes of experiment the quantities were not taken by measure, but every charge of powder was separately weighed to the exact grain, and every charge of shot was counted; while the cartridge cases and wads were all of the best quality, and loaded with an equal amount of care.

Then it might be suggested that the powder was not uniform in strength. But, in order to secure the utmost regularity possible in this respect, we bought a number of canisters of the same powder, mixed the whole of their contents thoroughly together, in case there should be any variation between one and another, and then the mixture was placed in large glass jars, fitted with air-tight stoppers, in order to prevent any deterioration from contact with the atmosphere; and until the contents of one jar were used, another jar was not opened.

The necessity for strict precautions was rendered apparent when we had to try the preliminary experiments for obtaining the standard velocity of 1160 ft.sec. The difference of a single grain in the charge of powder made a decided alteration in the velocity. For instance, 37grs. of the powder might, with one gun, give an average of nearly 20 f.s. below the standard, while 38grs. might give nearly the same difference in excess. Of course it was not desirable to resort to fractions of a grain; so we had to adopt the charge which gave the nearest approximate result; and even then (as will be seen in the table given above) the average of the right barrel was 1152 f.s., while that of the left came up to 1161 f.s., and there were considerable variations between the highest and lowest in both barrels.

Certainly such an amount of precaution as was here taken could never be exercised with cartridges intended for everyday use. And if these variations occur when charges are thus expressly loaded for purposes of experiment, it may readily be imagined that among the numberless cartridge cases filled for commercial purposes, by machines, or by gunmakers' assistants, or ironmongers' apprentices, there is likely to be much more irregularity in loading, and far greater diversity of result.

The Influence of the Caps.

As regards the differences exhibited by cartridges loaded for experimental purposes, we think that variations in strength of percussion caps have much more influence on the result than is generally acknowledged. With individual caps, however, it is practically impossible to trace cause and effect in the same distinctive way as the results of any variation in the charge of powder or shot can be followed out. You may have a hundred cartridge cases of the same brand, with caps apparently all alike, but you do not know what amount of detonating composition is contained in each; and if you remove the composition for the purpose of weighing it, the cap is thus rendered useless for firing purposes; while if you fire a cartridge that gives abnormal results, you cannot afterwards ascertain what quantity of fulminate was contained therein.

In an article published in the *Field* of June 20, 1891, an attempt was made to throw some light upon this subject. A large number of caps were examined, and they were found not only to differ as regards the chemical components of their respective detonating mixtures, but also in the quantity of composition inserted in the caps. Some manufacturers make caps of different sizes, in which the large caps intentionally contain more composition than the smaller ones; but we shall here only allude to those which are of the ordinary size, and in which any differences of quantity may be supposed to arise merely from the common vicissitudes that occur during the process of manufacture. In the caps made by one firm (which we will designate as X), the quantity of composition found therein amounted, on the average, to about one quarter of a grain; or (to state it more explicitly by metric weights) 16 milligrams. But out of 100 caps, only 21 were found to be of this average weight; while 3 per cent. of the caps contained only 11 milligrams of composition, 3 per cent. contained 12mgm., 8 per cent. had 13mgm., and so on, gradually increasing in quantity, step by step, until 19mgm. were found in 8 per cent., 20mgm. in 3 per cent., and 2 per cent. contained 21mgm. Hence it is apparent that some of the caps contained almost exactly double the amount of composition that was found in others, with every possible variation between the two extremes.

With another sample of caps (which we designate as Y) the average weight of composition in 100 caps was 22 milligrams, while the smallest quantity was 16mgm., and the largest 24mgm.

It is easy to imagine that, with such differences, there are likely to be different rates of ignition in the gun, and that some powders would be more affected than others. In the *Field* of Sept. 12, 1891, we published details of some experiments which we had carried out with these two kinds of cartridge cases (X and Y). The caps in the latter generally have the reputation of being somewhat stronger than the other. With black powders, however, there was but little difference between the results produced by the two kinds of caps; and, indeed, the crusher-gauge records with black powders showed rather lower pressures with the caps supposed to be the stronger of the two. With nitro-compounds, on the other hand, the facts were reversed; and here the Y cartridge cases exhibited pressures varying from 10 to 20 per cent. higher than those shown by the X cartridges; though none of them were so high as to be dangerous. It is obvious, however, as regards nitro powders, that variations in the strength of ignition, which have little or no effect with black powders, have a decided influence on their smokeless competitors, both with respect to velocity and recoil.

Here we will give a brief summary of results obtained with a gun cut down from 30in. to 26in. and 22in. After each reduction in length the barrel was rebored, so as to give the same pattern as before; and the weight of metal cut off the barrel was compensated on the recoil machine, in order to place the recoil records on exactly the same footing with respect to weight of gun. The following figures are the averages of a series of rounds from both kinds of cartridge cases, loaded with equal charges of three kinds of nitro powders (42grs. and 1⅛oz. of shot) and fired under similar conditions:

	Cartridges.	30 inch Barrels. Velocity. Ft.sec.	Recoil. Ft.lb.	26 inch Barrels. Velocity. Ft.sec.	Recoil. Ft.lb.	22 inch Barrels. Velocity. Ft.sec.	Recoil. Ft.lb.
A powder	X cases	1113	26·9	1075	24·9	988	24·5
	Y cases	1136	27·6	1081	26·8	1015	26·6
B powder	X cases	1106	26·7	1033	23·0	964	23·2
	Y cases	1135	27·3	1069	25·3	1016	24·2
C powder	X cases	1110	27·5	1016	24·9	991	24·7
	Y cases	1150	28·9	1071	27·1	1024	26·4

If, then, the average difference in strength between t' e caps in X cases and those in Y cases produced such marked results as are here shown, is it not feasible to suppose that the individual variations from round to round (which, as a rule, are much more pronounced with nitro-compounds than with black powders) may be due to individual differences in strength between successive caps?

To demonstrate the difference in regularity shown by six rounds of black powder and six rounds of nitro powder, loaded in the same cartridge cases, with the same wads, and fired out of the same gun, under the same conditions, we extract the following particulars from our report of the trials we carried out with guns of 12, 16, and 20 bores, about eighteen months ago. We may add that, in this table, the velocities were not taken for the same short distance as those above, but here they are the mean velocities for 40 yards.

16-BORE GUN.

		Velocity and Recoil, taken simultaneously.					Averages.
Black powder.	Velocity...	845	849	850	851	851	853 = 850 ft.sec.
	Recoil.....	30·0	30·8	30·0	31·0	31·1	31·5 = 30·7 ft.lb.
Nitro powder.	Velocity...	828	845	849	850	851	870 = 849 ft.sec.
	Recoil.....	23·6	24·9	25·0	24·8	25·2	25·0 = 24·8 ft.lb.

The rounds are not printed in the order of firing, but are arranged numerically, so as to facilitate reference. It will be seen that, as regards the average, there was but 1 f.s. difference between the black and the nitro powder. There was a marked contrast, however, as regards the individual rounds; for between the highest and lowest of black there was only 8 f.s. of variation; whereas between the highest and lowest of the nitro-compound the difference was 42 f.s. Now we do not believe that this wide distinction was due to any irregularity in the nitro powder itself; but our impression is that the results shown were brought about by variation in the quantity of detonating composition contained in the caps. This variation has but little effect on the black gunpowder; for that is rendered comparatively inert by the 60 per cent. solid residue which tempers the 40 per cent. of gaseous products. But with the nitro-compounds there is scarcely any solid residue to temper the 95 per cent. or more of gaseous matter; and a little excess or deficiency of energy in the contents of the cap makes all the difference in the amount of explosive force exhibited by the powder.

With the new concentrated powders we consider the difference of strength in the cap to be of much more importance than it is with the older nitro-compounds; and we believe that some of the instances of burst guns, that have lately been heard of, have been due to a weak cap only igniting the concentrated powder just sufficiently to drive the shot a few inches up the barrel, without having the power to expel it; and consequently, when the next cartridge is inserted and fired, the obstruction in front causes the barrel to burst.

Now, however, we must return to the records of the week's doings, which are as follows:

12-BORE, No. 1906; weight, 4lb. 14oz.; barrels, 24in.

RIGHT BARREL, 40grs. powder; 1oz. of shot (270 pellets); gas pressure, 1·79 tons per sq. inch.

	40 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	23	23	24	18	17	20	87	133	1141	28·9
2	40	28	27	21	22	12	116	154	1167	34·3
3	33	25	23	19	17	14	100	170	1158	34·0
4	23	25	20	23	16	13	96	174	1145	30·2
5	40	29	24	16	13	17	109	161	1163	33·8
6	43	30	27	13	14	15	113	157	1176	35·0
7	38	27	21	27	26	25	113	157	1154	30·7
8	29	33	22	17	21	13	101	169	1149	33·9
9	39	28	26	19	19	15	112	158	1172	34·7
10	48	25	29	15	13	17	117	153	1163	33·0
Aver...	36	27	24	19	18	16	106	164	1159	32·7

	30 YARDS PATTERN.								
Round.	1st. ring.	2nd. ring.	3rd. ring.	4th. ring.	5th. ring.	6th. ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	46	37	34	26	24	13	143	127	
2	54	40	38	26	26	15	158	112	
3	73	47	30	19	15	7	169	101	
4	61	39	26	22	20	13	143	122	
5	71	50	32	29	19	20	189	88	
6	51	50	29	31	19	14	161	109	(As above.)
7	66	46	40	25	22	20	177	93	
8	43	45	35	27	20	21	150	120	
9	55	38	37	30	18	16	160	110	
10	48	44	34	27	15	19	158	117	
Aver...	57	44	33	26	20	16	160	110	

	20 YARDS PATTERN.								
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30 n.	Velocity. Recoil.
1	101	55	33	19	16	17	208	63	
2	97	60	37	28	11	10	222	43	
3	105	68	41	21	9	9	235	35	
4	78	85	40	22	15	8	229	41	
5	100	71	33	20	18	11	224	46	
6	119	58	29	17	12	6	223	47	(As above.)
7	88	80	43	21	17	14	232	38	
8	91	78	48	23	17	3	235	35	
9	117	58	37	23	18	9	234	36	
10	99	69	34	26	7	7	228	42	
Aver...	99	68	37	22	14	9	226	44	

LEFT BARREL, 40grs. powder; 1oz. of shot (270 pellets); gas pressure, 1·79 tons per sq. inch.

	40 YARDS PATTERN.								
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	61	58	27	27	24	17	173	97	
2	62	62	40	23	16	13	187	83	
3	80	31	39	26	15	12	176	94	
4	56	43	31	29	21	25	159	111	
5	67	46	27	34	19	23	174	96	
6	59	45	30	25	20	16	159	111	(As above.)
7	63	60	36	21	17	13	180	90	
8	56	43	35	20	17	15	154	116	
9	66	51	33	28	16	17	178	92	
10	71	47	27	21	13	19	166	104	
Aver...	64	49	32	25	18	17	170	100	

	30 YARDS PATTERN.								
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	87	63	41	29	19	13	220	50	
2	65	59	42	33	20	12	199	71	
3	117	77	25	24	14	5	243	27	
4	79	60	36	29	23	16	204	66	
5	85	59	45	30	9	7	219	51	
6	121	61	33	21	8	3	236	34	(As above.)
7	97	55	42	31	11	11	225	45	
8	134	52	30	18	7	8	234	36	
9	83	57	46	26	13	8	212	58	
10	48	38	43	22	21	19	151	119	
Aver...	92	58	38	26	14	10	214	56	

	20 YARDS PATTERN.								
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	164	37	10	3	1	0	214	56	
2	185	38	17	9	3	1	244	26	
3	171	49	20	11	5	3	251	19	
4	178	41	14	5	1	0	238	32	
5	152	60	19	12	7	4	243	27	
6	166	40	11	9	4	2	226	44	(As above.)
7	182	49	13	6	2	3	240	30	
8	145	71	18	7	7	5	241	29	
9	171	50	14	4	2	3	249	21	
10	156	56	24	15	5	2	251	19	
Aver...	166	49	16	8	4	2	239	31	

12-BORE, No. 1906; weight, 4lb. 14oz.; barrels, 24in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, 38grs. powder; ¾oz. of shot (236 pellets); gas pressure, 1·25 tons per sq. inch.

	40 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10 yards.) Ft.sec.	Recoil. Ft.lb.
1	24	32	19	19	16	28	94	142	1167	27·7
2	30	41	20	18	19	17	103	127	1172	28·0
3	20	23	14	11	13	10	68	168	1163	27·1
4	35	33	21	22	14	12	111	125	1145	26·0
5	27	27	22	19	17	20	95	141	1181	27·5
6	29	28	25	29	12	13	111	125	1154	25·1
7	21	24	26	20	18	11	91	145	1163	26·3
8	30	26	18	13	16	13	87	149	1173	25·9
9	33	29	14	17	15	15	93	143	1141	25·7
10	24	38	20	17	30	9	99	137	1186	30·0
Aver...	27	30	20	18	17	14	95	141	1164	27·0

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	56	41	27	19	16	12	143	93		
2	44	36	30	37	19	9	147	89		
3	61	40	21	28	14	5	145	91		
4	35	30	24	30	25	22	119	117		
5	36	42	31	31	18	11	140	96		
6	47	45	37	28	14	6	152	84		(As above.)
7	53	30	34	27	22	14	144	92		
8	40	33	33	26	17	9	133	133		
9	26	25	16	20	15	12	87	149		
10	65	46	36	21	13	16	168	68		
Aver...	46	37	29	26	17	12	138	98		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring	4th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	90	51	35	20	10	7	196	40		
2	71	64	40	20	9	14	195	41		
3	113	52	34	13	7	5	211	25		
4	90	68	41	20	5	10	214	22		
5	84	67	33	19	8	2	203	33		(As above.)
6	108	60	32	11	10	5	211	25		
7	101	57	44	23	6	0	225	11		
8	92	58	36	18	15	13	204	32		
9	103	55	33	24	10	1	215	21		
10	90	44	19	19	15	18	179	64		
Aver...	94	57	35	19	9	7	205	31		

LEFT BARREL, 38grs. powder; ⅞oz. of shot (236 pellets); gas pressure in barrel, 1·25 tons per square inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	38	28	37	17	16	168	78		
2	48	48	25	24	15	90	140	96		
3	48	36	28	21	18	14	133	103		
4	34	32	29	21	15	24	116	120		
5	63	36	30	25	13	20	154	82		
6	44	47	33	22	16	15	146	90		(As above.)
7	37	31	31	29	15	14	128	108		
8	55	42	23	23	14	12	143	93		
9	64	31	27	20	22	13	142	94		
10	49	35	24	28	22	18	136	100		
Aver...	50	37	28	25	17	16	140	96		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	69	47	43	34	9	10	193	43		
2	74	49	29	32	18	12	184	52		
3	70	43	30	23	22	13	166	70		
4	88	47	29	21	14	11	185	51		
5	76	49	30	15	14	14	170	66		
6	102	53	16	23	10	7	193	43		(As above.)
7	82	63	25	17	15	14	187	49		
8	91	44	20	20	14	12	175	61		
9	63	69	33	24	16	8	189	47		
10	112	50	19	14	7	9	195	41		
Aver...	83	51	27	23	14	11	188	58		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	128	48	24	12	6	2	212	24		
2	154	44	14	10	4	0	222	14		
3	138	53	22	7	7	1	219	17		
4	153	57	9	8	4	2	221	15		
5	166	35	9	2	3	0	212	24		
6	174	36	8	2	1	0	220	16		(As above.)
7	141	51	23	3	2	3	218	18		
8	139	48	26	10	3	1	223	13		
9	126	44	24	15	5	2	209	27		
10	161	44	14	5	1	0	224	12		
Aver...	148	46	17	7	4	1	208	18		

12-BORE, No. 2502; weight, 5lb. 4oz.; barrels, 24in.

RIGHT BARREL, 40grs. powder; 1oz. of shot (270 pellets); gas pressure in barrel, 1·81 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10 yds.) Ft. sec.	Recoil. Ft. lb.
1	32	30	26	20	10	16	108	162	1176	31·0
2	20	32	26	23	18	13	101	169	1149	30·0
3	29	30	24	29	14	12	112	158	1141	29·7
4	40	23	27	19	16	15	109	161	1154	30·6
5	35	23	21	14	18	10	93	172	1160	30·4
6	31	36	29	22	20	12	118	153	1133	29·8
7	37	35	30	29	14	16	131	139	1167	30·7
8	19	24	25	18	22	19	86	184	1181	31·1
9	27	37	27	27	19	14	118	152	1136	30·1
10	30	31	30	23	17	17	114	156	1163	31·2
Aver...	30	31	26	22	17	14	109	161	1156	30·5

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	67	55	35	34	15	15	191	79		
2	59	47	40	29	13	12	175	95		
3	44	56	41	27	19	18	168	102		
4	60	45	31	23	18	13	159	111		
5	32	30	24	20	17	17	103	164		
6	56	34	45	29	20	13	164	106		(As above.)
7	44	42	31	30	18	11	147	123		
8	48	36	42	36	21	16	162	108		
9	51	38	38	31	18	12	158	112		
10	42	44	37	25	20	13	148	122		
Aver...	50	43	36	28	18	14	157	113		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	58	58	45	29	4	3	190	80		
2	86	60	39	22	5	9	207	63		
3	101	55	40	28	12	5	224	46		
4	77	65	44	19	17	8	205	65		
5	98	80	31	17	13	4	226	44		
6	107	71	27	12	11	11	217	53		(As above.)
7	92	70	37	21	18	9	210	60		
8	82	52	33	29	13	6	196	74		
9	103	84	46	17	9	2	250	20		
10	42	57	53	39	11	5	191	79		
Aver...	85	65	39	23	11	5	212	58		

LEFT BARREL, 40grs. powder; 1oz. of shot (270 pellets); gas pressure in barrel, 1·81 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	45	27	24	24	15	156	114		
2	17	12	20	8	7	5	57	213		
3	40	43	34	26	22	17	143	127		
4	61	39	33	21	18	13	151	116		
5	38	35	39	31	19	21	143	127		
6	52	31	35	27	23	8	145	125		(As above.)
7	28	27	28	24	20	16	107	163		
8	45	46	31	33	17	11	155	115		
9	81	41	25	26	16	10	173	97		
10	77	53	31	21	14	18	182	88		
Aver...	50	37	30	24	18	13	141	129		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	107	58	27	25	12	9	217	53		
2	111	60	36	27	11	6	234	36		
3	88	71	40	21	12	5	220	50		
4	98	70	31	23	20	6	223	48		
5	120	51	33	18	16	7	227	43		
6	105	49	33	24	18	6	211	59		(As above.)
7	116	51	31	19	14	8	217	53		
8	46	27	23	20	11	5	116	154		
9	112	52	28	25	7	9	217	53		
10	130	57	32	18	9	11	237	33		
Aver...	103	55	32	22	13	7	212	58		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	164	45	17	10	9	7	236	34		
2	108	58	39	15	5	2	220	50		
3	129	33	39	26	12	10	226	44		
4	148	48	21	14	7	3	231	39		
5	84	46	37	27	21	11	194	76		
6	148	66	15	9	5	3	238	32		
7	153	40	20	11	3	5	213	57		(As above.)
8	98	59	31	20	11	6	208	62		
9	132	54	28	17	15	1	231	39		
10	132	60	31	21	11	4	244	26		
Aver...	129	51	28	17	10	5	225	45		

12-BORE, No. 2502; weight, 5lb. 4oz.; barrels, 24in.
[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, 38grs. powder; ¾oz. of shot (236 pellets); gas pressure in barrel, 1·43 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10 yds.) Ft. sec.	Recoil. Ft. lb.
1	34	33	29	30	14	14	126	110	1158	26·1
2	14	12	9	11	20	21	46	190	1149	25·2
3	42	40	22	22	19	17	196	110	1176	27·0
4	36	29	27	27	15	18	119	117	1141	25·3
5	29	33	24	26	17	20	112	124	1167	26·3
6	40	22	31	25	20	19	118	118	1163	26·6
7	33	26	20	23	22	15	102	134	1149	26·0
8	33	34	28	20	21	18	120	116	1176	26·8
9	39	21	34	30	27	11	124	112	1181	27·5
10	16	14	12	14	23	20	56	180	1149	25·8
Aver...	32	26	24	23	20	17	105	131	1161	26·8

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	18	16	18	11	20	11	63	173		
2	47	35	35	28	14	17	145	91		
3	59	33	29	20	17	17	146	90		
4	44	47	29	23	13	10	143	93		
5	79	49	25	24	15	7	177	59		
6	58	41	30	17	19	11	146	90		(As above.)
7	36	25	27	23	22	12	111	125		
8	61	43	22	20	18	13	146	90		
9	72	51	30	20	16	10	173	63		
10	45	31	31	18	6	18	125	111		
Aver...	52	36	28	20	16	13	138	98		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	106	55	24	16	8	10	201	35		
2	112	56	22	18	10	4	208	28		
3	100	68	27	12	8	5	207	29		
4	101	48	30	15	13	10	194	42		
5	123	51	27	12	10	0	213	23		
6	94	60	31	14	14	4	199	37		(As above.)
7	82	63	39	21	12	6	205	31		
8	106	49	25	19	17	9	199	37		
9	99	52	22	20	14	11	193	43		
10	119	28	33	15	10	6	205	31		
Aver...	104	54	28	16	12	6	202	34		

LEFT BARREL, 38grs. powder; ¾oz. of shot, (236 pellets); gas pressure in barrel, 1·43 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	23	25	32	26	26	19	105	131		
2	51	29	32	20	20	22	132	104		
3	32	33	26	27	25	19	125	111		
4	45	45	26	24	24	12	140	96		
5	33	33	37	22	19	21	130	106		
6	47	36	27	27	18	11	137	99		(As above.)
7	23	39	33	20	19	15	119	117		
8	49	30	23	25	21	13	132	104		
9	23	26	11	16	11	19	76	160		
10	42	40	32	27	23	18	141	95		
Aver...	37	34	29	23	21	17	123	113		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	100	43	28	19	19	8	190	46		
2	42	48	40	25	15	13	155	81		
3	76	56	33	21	12	11	186	50		
4	106	47	17	19	10	5	189	47		
5	57	41	36	26	14	7	160	76		
6	105	44	21	14	9	6	184	52		
7	90	55	33	16	12	7	194	42		
8	66	50	31	21	13	10	186	68		(As above.)
9	56	46	37	33	20	17	173	64		
10	39	31	41	41	25	27	152	74		
Aver...	74	46	33	23	15	11	175	61		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside. 30in.	Velocity.	Recoil.
1	125	44	17	9	5	2	195	41		
2	85	51	53	20	10	6	208	28		
3	129	53	18	10	7	3	210	26		
4	139	33	22	16	6	1	215	21		
5	99	66	17	14	9	0	196	40		
6	112	44	25	17	6	0	198	38		(As above.)
7	80	61	37	20	12	2	198	38		
8	140	40	19	12	6	7	211	25		
9	112	50	23	10	11	8	195	41		
10	122	56	19	10	8	5	207	29		
Aver...	114	50	25	14	8	3	208	33		

"Field, March 28, 1896; Vol. 87, p. 456.)

HITHERTO THE GUNS TRIED have all been 12-bores; and now we proceed to state the results of experiments with some guns of smaller gauge. The records of the trials published last week confirm certain results of former experiments, by showing that short barrels require more powder than long barrels, in order to impart equal velocity to the shot; and that such increase of the charge produces a greater amount of recoil, as well as greater pressure of the powder gases within the barrel. With smaller gauges we may expect, when the charges used are the same as those in larger bores, that there will be greater pressure in the barrel, and consequently higher velocity. It may be stated as an axiom that the greater the difference between the pressures at the breech and at the muzzle, the greater will be the ballistic effect obtained from any given weight of powder. Accordingly, the powder charges with 16-bores, in order to impart 1160 f.s. velocity to 1oz. of shot, are likely to require some reduction, as compared with 12-bores; while the 20-bore charge will probably have to be reduced in comparison with the 16-bore.

This increase of pressure with diminution of gauge appears to be due to the comparatively greater length and weight of the charge in the smaller bore, in proportion to the area of the wad which the powder-gases act upon. For instance, supposing that the powder occupied a space of 1 inch in length in a 12-bore gun, the same charge of powder, when transferred to a 16-bore, would occupy 1·2 inch in length, and in a 20-bore 1·4 inch. The shot charge would be lengthened in similar proportion; and with each such increase in length, the frictional resistance of the shot in the barrel would be augmented, and that resistance would enhance the pressure of the powder-gases.

People not unfrequently speak as though the increase of the powder charge were the prime cause of the development of explosive force in a gun. But resistance to the expansion of the gases is a much more potent factor. For example, 3drs. (*i.e.*, 82grs.) of No. 6 black powder, with 1⅛oz. of shot, give a pressure of little more than 2 tons per square inch in a 12-bore shot gun, which is ·729 inch in diameter. In the Snider rifle, of ·577 gauge, 70grs. (or about half a dram less) of the same powder, with a bullet of 480grs. (or rather under 1⅛oz.), the pressure increases to about 2½ tons. In the Martini-Henry rifle, with 85grs. of similar powder, and a bullet of exactly the same weight as the Snider, but longer, the resistance in the ·450 barrel causes the force of the powder gases to rise to about 5 tons. But the most marked difference occurs in the ·303 rifle, where the resistance of the long nickel-covered bullet, with the rapid twist of the rifling, raises the stress of the powder gases in the barrel to about 18 tons per square inch, or nine times as much as in the 12-bore shot gun; and yet the charge of black powder is only 30½grs. (or about 1⅛ drams), and the weight of the bullet is 215grs. (or under half an ounce).

Variations of Stress in 12, 16, and 20 Bores.

To return to smooth-bore guns, however, the experiments which we carried out with 12, 16, and 20 bores, about eighteen months ago, gave some very curious results, as showing the difference in amount of stress exhibited by equal charges of powder in guns of different gauge, notwithstanding that the shot-charge was reduced in weight for the smaller bores. The charges were 3drs. each for the black powders, and the corresponding equivalent for the nitro-compounds.

Powders.	12-Bore. (1¼oz. shot.) Stress.	16-Bore. (1oz. shot.) Stress.	20-Bore. (⅞oz. shot.) Stress.
Black:			
No. 2	3·33 tons	3·74 tons	4·29 tons
No. 4	2·23 „	2·89 „	3·63 „
Nitros:			
A	1·65 tons	2·78 tons	3·31 tons
B	1·43 „	2·53 „	3·32 „
C	3·25 „	3·97 „	6·05 „
D	1·68 „	4·03 „	7·53 „

The above nitro powders were all of kinds which can be used with the same cartridge cases as black powder. We have not included any of the new concentrated powders which require special cases and caps; and we do not say that all the above powders would give the same pressures now, because we believe some of them have been modified since these results were first published.

It may be thought, no doubt, that few people would ever be likely to use 3drs. of powder in a 20-bore; and with black powders that would be quite true; but with the new concentrated powders still more excessive charges have been inserted in cartridge cases by ignorant loaders. Without dwelling on that, however, we may point out that the above-mentioned powders varied widely in pressure in the three bores when they were used in ordinary loads. This will be seen by the following records, which show the amount of stress in the chamber of the gun when the charges of each were regulated to impart equal velocity to the shot. The standard speed then adopted, with each of the three guns, was 850 f.s. mean velocity for 40 yards (which is equivalent to about 1220 f.s. muzzle velocity with No. 6 shot). But although the charges of powder were thus regulated to impart equal energy to the shot-charge, the amount of propulsive force developed was very different; and the proportion of recoil, too, was not uniform, as will be seen by the following figures:

Powders.	12-Bore. (1¼oz. shot.)		16-Bore. (1oz. shot.)		20-Bore. (⅞oz. shot.)	
Black:	Stress.	Recoil.	Stress.	Recoil.	Stress.	Recoil.
No. 2	3·03 tons.	31·1 ft.lb.	3·49 tons.	30·0 ft.lb.	3·59 tons.	28·8 ft.lb.
No. 4	2·37 „	34·8 „	2·90 „	30·7 „	3·09 „	31·3 „
Nitros:						
A	1·93 tons.	27·6 ft.lb.	2·10 tons.	25·7 ft.lb.	2·45 tons.	24·5 ft.lb.
B	1·54 „	28·3 „	2·01 „	24·8 „	2·70 „	24·7 „
C	2·33 „	27·1 „	3·18 „	26·1 „	4·19 „	25·6 „
D	1·58 „	27·2 „	2·25 „	26·3 „	3·57 „	26·0 „

It is a curious fact, moreover, that although the stress with all these sporting powders increased more or less in the smaller bores, the slow-burning powder which is especially used for the proof of guns does not exhibit a similar development of force, but the pressure remains nearly uniform in the three bores. In some experiments tried at the same time, with the regulation proof charges of powder and shot, the records were 4·12 tons with the 12-bore, 4·06 tons with the 16-bore, and 4·23 tons with the 20-bore. It is well, therefore, that the new proof regulations [page 3] introduce an additional proof with No. 2 powder.

Atmospheric Effects on Velocity and Recoil.

As regards registration of recoil, for the information of those who have not seen the particulars previously published (*Field*, Sept. 20, 1890), we may briefly state that the instrument we use for this purpose directly records the result in foot-pounds. Thus, supposing a gun weighing 7lb. is attached to the movable part of the machine, the combined weight of the two is made up to 35lb., or five times the weight of the gun. Then the spring is so set as to give a *constant* resistance of 35lb.; and, as the scale is divided into fractions of a foot, a record is taken automatically of every round fired, to the nearest tenth of a foot-pound.

In order to ascertain whether the horizontal recoil thus registered would correspond with the upward lift of the gun against the force of gravity, we detached the spring from the machine, suspended the apparatus some yards above ground, and fired the gun downwards. The recoil of the gun, on being fired, then lifted up the combined weight of 35lb. to a distance corresponding with that of the horizontal recoil. And, further, in order to ascertain what the lift of the 7lb. gun alone would be, when entirely detached from the machine, the gun was suspended alongside a measured scale, and it was found that then, on being fired downwards, the gun was lifted up to between 4ft. and 5ft., according to the nature of the charge fired. We think, therefore, that the records given by the machine are practically as accurate as they can well be made.

We have entered into these details because it has not unnaturally been supposed, as our records are considerably in excess of the ordinary theoretical estimates, that there may possibly be some fundamental error in the machine which exaggerates all the results. And one hears it said, from time to time, that, inasmuch as "action and reaction are equal," such and such statements cannot be correct.

We quite agree as to action and reaction being equal; but if important factors are omitted in the estimate of the amount of "action," it is not surprising if the amount of "reaction" does not accord therewith.

One of the factors which seem to be lost sight of with regard to recoil is the influence of the atmosphere. As mentioned in the *Field*, several years ago, we tried the effect of exhausting the air in the barrel by means of an air pump, and at the same time ascertained the velocity of the bullet (a 12-bore spherical ball) by use of the chronograph. The muzzle velocity of the bullet was 1245 f.s. when fired from the gun in its ordinary condition. When the column of air was exhausted from the barrel, the muzzle velocity was 1285 f.s. With this increase of energy in the bullet the energy of recoil (if "action and re-action" were employed in the limited sense here referred to) should have been raised several foot-pounds; but, on the contrary, it was slightly reduced.

On another occasion, whilst we were trying experiments with shortened barrels, we found that when several inches were cut off the barrel, the velocity of the shot was decreased, as we expected; but the recoil was occasionally increased in a way which we did not expect. A diagram given in the *Field* of Aug. 29, 1891, showed the variations of velocity and recoil with different lengths of barrel; and we confess we were puzzled by some of the results. But it has since occurred to us that the difference in weight of the atmosphere had probably a much greater influence than we then imagined. On one day, the temperature was 36°, and on another it was 70°. This would give a difference of about 7 per cent. in the weight per cubic foot of the atmosphere on the two days. This greater density, in the one case, would retard the passage of the shot through the air, and the chronograph would consequently record a lower velocity. On the other hand, the column of air in the barrel being also increased in weight, would have a somewhat similar effect to an increase in weight of the shot, so that there would thus be an increase of the back-thrust registered on the recoil machine; and this, we imagine, will give a clue to the reason why the recoil increased simultaneously with a decrease in velocity.

The ordinary method of estimating recoil may be briefly stated thus:—If a bullet weighing 1oz. is fired out of a gun weighing 100oz. (*i.e.*, 6¼lb.), the gun will move backward with 100th part of the speed with which the shot leaves the muzzle. Consequently, if the bullet has a velocity of 1200 feet per second, the gun would be driven back with the speed of 12 feet per second. And as the energy is proportionate to the square of the velocity, the energy contained in the bullet would amount to 1400 ft.lb. and the energy of the gun's recoil would be 100th part of that amount, or 14 ft.lb.

So far so good. But practical experiments have shown that the velocity of recoil is higher than is provided for by this theory; and that though it has been proposed to add a portion of the weight of the powder to the weight of the shot, that does not nearly suffice to make theory accord with ascertained facts. In the *Field* of Dec. 10, 1892, we published particulars showing how the velocity of recoil, as ascertained by chronograph, varied with different kinds of powder; and that the backward movement of the gun, instead of having the theoretic speed of, say, 12 ft.sec., as compared with the shot-velocity of about 1200 ft.sec., a fine-grain black powder gave a recoil velocity of about 18 f.s., or 6 f.s. in excess; a coarse-grain black powder gave 5 f.s. excess, and a nitro-compound gave 4 f.s. excess. And as the energy of recoil, in like manner as the energy of the projectile, varies in proportion to the square of the velocity, the differences in the recoil records were thus accounted for. We may add, also, that the excess, which amounted to 3 or 4 f.s. in a long barrel, increased to 5 or 6 f.s. in a shorter one.

That short barrels *do* give more recoil than long ones—at all events with nitro powders—may be seen from some records published in the *Field* of Dec. 12, 1891. There a 12-bore of very unusual length was tried—the barrels being 45 inches long; and the records made therewith were put in comparison with those of other barrels using

exactly the same charge. The results with two nitro powders were as follows:

Powder.		30 inch Barrel.	34 inch Barrel.	45 inch Barrel.
A, 42grs.	Velocity	1113 ft.sec.	1119 ft.sec.	1116 ft.sec.
	Recoil	*26·9 ft.lb.*	*25·1 ft.lb.*	*24·8 ft.lb.*
B, 42grs.	Velocity	1106 ft.sec.	1120 ft.sec.	1128 ft.sec.
	Recoil	*26·7 ft.lb.*	*25·8 ft.lb.*	*23·9 ft.lb.*

Here it will be seen that there was little difference between the records with the two nitro powders; but while the velocity slightly increased in most instances, the recoil always diminished with the longer barrel. And lest any misconception should arise as to this being due to the respective weight of the guns, we may mention that such difference was duly compensated for—each gun being taken as 7lb. in weight; and when the 45in. gun was tested at its full weight (viz., 8lb. 10oz.), the record was 19·6 ft.lb. with powder A, and 19·4 ft.lb. with powder B, instead of the amounts stated above.

Curiously enough, however, the recoil did not fall off in the same manner with two black powders which were also tried. The results with these were as follows:

Powder.		30 inch Barrel.	34 inch Barrel.	45 inch Barrel.
No. 2, 3drs.	Velocity	1128 ft.sec.	1147 ft.sec.	1202 ft.sec.
	Recoil	*33·2 ft.lb.*	*33·2 ft.lb.*	*35·1 ft.lb.*
No. 6, 3drs.	Velocity	1051 ft.sec.	1094 ft.sec.	1071 ft.sec.
	Recoil	*27·0 ft.lb.*	*27·6 ft.lb.*	*30·0 ft.lb.*

When the 45in. gun was tried with its full weight of 8lb. 10oz., the recoil was reduced to 28·5 ft.lb. with No. 2 powder, and to 24·3 ft.lb. with No. 6.

We attribute the different behaviour of the two classes of powder mainly to the fact that, owing to there being practically no solid residue in the decomposed nitro powders, the gases become more and more chilled as they travel up the length of the barrel, and thereby lose their expansive force; so that by the time they get up towards the extremity of a very long tube, they have scarcely sufficient strength left to overcome the friction of the shot in the barrel; and consequently, although the energy previously imparted to the shot serves to carry it forward, the friction acts as a brake on the backward movement of the barrel. With black powder, however, the effect is different. There is about 60 per cent. of solid residue in the products of combustion, and this carries a very large amount of heat up to the muzzle, as evidenced by the incandescent fluid mass which is ejected from the barrel when black powder is fired. Consequently the expansive force of the gases still suffices to overcome the friction of the shot-charge, and add to the amount of the recoil; and the coarse-grain black powder, which burns for a longer distance up the barrel, adds more to the recoil than the fine-grain, which undergoes complete combustion near to the breech.

16-BORE, No. 854; weight, 5lb. 15oz.; barrels, 28in.

RIGHT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 2·46 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	69	55	24	27	14	16	175	95	1176	25·4
2	54	41	32	26	23	15	153	117	1168	25·0
3	49	40	30	22	25	13	141	129	1168	24·9
4	67	44	34	26	19	13	171	99	1169	24·5
5	60	51	36	31	22	20	178	92	1145	24·7
6	54	49	23	34	22	17	160	110	1169	25·2
7	55	39	33	21	19	15	153	117	1179	25·6
8	61	34	30	32	24	21	157	113	1160	24·8
9	73	40	27	27	13	14	166	104	1158	24·8
10	66	43	34	30	22	13	178	97	1172	24·7
Aver.	61	44	31	28	21	16	163	107	1165	25·0

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity.	Recoil.
1	79	41	33	34	24	11	187	83		
2	88	50	27	28	19	13	198	77		
3	74	76	30	20	10	11	200	70		
4	72	65	36	30	17	18	208	67		
5	98	59	29	28	5	11	209	61		
6	92	47	40	30	15	20	209	61	(As above.)	
7	51	55	39	36	18	14	181	89		
8	104	57	23	21	10	18	205	65		
9	85	46	35	29	19	12	195	75		
10	77	63	37	24	15	15	201	69		
Aver.	82	56	33	27	15	14	196	72		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity.	Recoil.
1	135	72	19	11	2	1	237	33		
2	155	36	14	6	2	3	211	59		
3	152	47	14	2	4	1	215	55		
4	123	73	30	5	1	4	236	34		
5	160	44	23	8	3	0	235	35		
6	130	59	29	13	6	3	231	39	(As before.)	
7	149	60	10	7	3	0	226	44		
8	151	35	11	5	1	0	202	68		
9	164	33	28	17	4	4	242	28		
10	140	68	21	5	1	0	234	36		
Aver.	146	53	20	8	3	2	227	43		

LEFT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 2·46 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity.	Recoil.
1	43	36	26	23	13	26	128	142		
2	77	58	32	23	21	10	190	80		
3	66	53	28	24	18	17	171	99		
4	44	55	29	26	13	23	154	116		
5	50	44	31	25	20	18	150	120		
6	36	26	32	19	20	18	113	157	(As above.)	
7	62	52	41	21	20	17	176	94		
8	58	44	33	27	19	22	163	108		
9	63	41	29	21	9	9	154	116		
10	80	37	39	20	12	11	176	94		
Aver.	58	45	32	23	16	17	157	113		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity.	Recoil.
1	102	54	31	24	11	9	211	59		
2	91	63	47	19	10	9	220	50		
3	75	51	42	21	19	8	189	81		
4	66	55	45	22	12	6	188	82		
5	73	59	50	22	13	17	204	66		
6	98	49	29	30	17	11	206	64	(As above.)	
7	112	65	40	21	9	5	238	32		
8	87	68	34	25	16	6	214	56		
9	100	71	31	20	7	7	232	48		
10	50	41	31	24	18	19	146	124		
Aver.	85	58	38	23	13	10	204	66		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity.	Recoil.
1	171	34	15	5	2	3	225	45		
2	165	46	11	13	4	1	235	35		
3	144	61	19	9	5	0	238	37		
4	62	52	33	30	16	21	177	93		
5	155	38	37	22	12	5	252	18		
6	107	53	36	18	12	7	214	56	(As above.)	
7	117	56	28	14	9	3	215	55		
8	152	46	7	4	4	0	209	61		
9	111	61	30	18	5	1	230	50		
10	165	27	12	4	2	2	208	62		
Aver.	135	47	23	14	7	4	219	51		

16-BORE, No. 854; weight, 5lb. 15oz.; barrels, 28in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, 35grs. powder; ¾oz. of shot (236 pellets); gas pressure, 1·21 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Out-side 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	76	46	24	23	13	15	169	67	1158	21·2
2	65	40	31	18	16	16	154	82	1154	21·0
3	39	39	35	26	21	22	139	97	1181	23·0
4	60	37	33	22	19	13	152	84	1172	22·4
5	52	38	33	19	10	16	142	94	1141	20·8
6	39	41	28	19	21	17	127	109	1172	22·5
7	48	35	29	20	17	18	133	104	1145	21·0
8	58	32	30	28	18	16	148	88	1168	21·7
9	52	45	32	23	15	18	152	84	1156	21·0
10	41	46	35	27	18	21	149	87	1169	22·0
Aver.	53	40	31	22	17	17	146	90	1161	21·7

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	80	52	34	23	18	11	189	47		
2	57	46	40	20	21	18	163	73		
3	83	51	24	23	16	7	180	56		
4	74	48	26	18	16	12	166	70		
5	68	57	33	25	13	8	182	54		
6	70	54	30	27	15	12	181	55		(As before.)
7	87	43	36	16	11	10	183	54		
8	95	55	28	15	8	9	198	43		
9	76	44	37	24	17	15	181	55		
10	88	46	23	17	14	17	178	63		
Aver...	78	50	31	21	14	13	179	57		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	129	40	18	11	7	2	198	38		
2	101	55	29	17	10	1	202	34		
3	145	28	23	14	5	0	210	26		
4	139	53	13	2	2	3	207	29		
5	158	25	20	3	6	4	206	30		
6	126	46	17	16	2	2	195	41		(As above.)
7	134	38	21	18	9	2	211	25		
8	155	33	9	2	4	3	199	37		
9	130	46	24	7	8	0	217	19		
10	142	39	19	5	4	3	205	31		
Aver...	136	40	19	8	6	2	205	31		

LEFT BARREL, 35grs. powder; ½oz. of shot (236 pellets); gas pressure, 1·21 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	56	33	37	21	11	13	146	90		
2	22	17	27	18	8	16	84	152		
3	58	40	39	20	17	14	157	79		
4	33	49	23	24	13	9	129	107		
5	50	42	36	19	18	13	147	89		
6	52	36	20	21	20	17	129	107		(As above.)
7	47	41	23	25	16	15	135	101		
8	58	50	25	22	22	12	155	81		
9	39	37	33	26	19	14	134	102		
10	54	43	30	27	17	16	153	83		
Aver...	47	39	29	22	16	14	137	99		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	95	50	31	18	8	8	194	42		
2	83	56	23	12	15	10	174	62		
3	80	51	27	19	16	7	177	59		
4	73	46	31	22	17	5	172	64		
5	94	43	44	20	11	6	200	36		
6	91	50	30	18	12	9	189	47		(As above.)
7	87	59	21	19	14	11	186	50		
8	83	50	33	21	9	10	186	50		
9	76	54	35	15	7	4	180	56		
10	100	52	30	16	11	10	198	88		
Aver...	86	51	30	18	12	8	186	50		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	136	40	20	6	3	0	202	34		
2	149	28	18	5	0	3	200	36		
3	151	30	19	13	1	4	218	28		
4	139	48	21	6	2	1	214	22		
5	160	34	16	7	3	2	217	19		
6	165	36	4	4	0	1	209	27		(As above.)
7	148	26	20	5	5	0	199	37		
8	146	47	13	4	1	2	210	26		
9	139	42	23	9	6	3	212	24		
10	107	53	35	11	4	5	206	30		
Aver...	143	38	19	7	2	2	206	28		

16-BORE, No. 1801; weight, 5lb. 8¼oz.; barrels, 27in.

RIGHT BARREL, 37grs. powder; 1oz. of shot (270 pellets); gas pressure, 2·64 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	37	24	26	21	18	18	108	162	1163	27·6
2	21	22	25	28	23	15	96	174	1151	28·0
3	33	20	21	9	14	15	83	187	1136	27·0
4	26	27	25	20	15	17	98	172	1136	27·0
5	25	25	29	23	19	20	102	168	1136	28·0
6	23	27	24	17	17	27	91	179	1158	27·4
7	38	28	30	24	16	14	120	150	1141	27·2
8	25	30	21	26	20	24	102	168	1172	28·1
9	29	26	23	25	23	22	108	167	1176	28·0
10	41	29	34	24	17	18	128	142	1167	27·8
Aver...	30	26	26	23	18	18	103	167	1162	27·6

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	40	51	26	23	23	21	140	130		
2	52	47	30	31	19	18	160	110		
3	70	33	40	25	20	17	173	97		
4	53	41	33	26	17	15	163	107		
5	61	55	36	34	14	20	186	84		
6	34	39	30	34	22	23	137	133		(As above.)
7	48	46	31	30	20	9	155	115		
8	65	45	36	27	17	17	173	97		
9	55	44	43	33	19	10	185	85		
10	44	52	39	35	21	12	170	100		
Aver...	53	46	35	30	19	16	164	106		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside. 30in.	Velocity.	Recoil.
1	86	51	43	38	21	13	218	52		
2	41	66	52	41	17	11	200	70		
3	50	73	40	37	24	15	200	70		
4	48	65	33	35	18	9	186	84		
5	105	66	28	14	18	15	213	57		
6	62	59	51	33	15	10	204	66		(As above.)
7	99	47	23	29	16	12	203	67		
8	29	37		49	35	24	161	109		
9	59	73	55	21	9	12	207	63		
10	93	54	37	18	19	13	202	68		
Aver...	67	59	42	31	19	14	199	71		

LEFT BARREL, 37grs. powder; 1oz. of shot (270 pellets); gas pressure, 2·64 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	40	26	28	25	19	17	119	151		
2	35	30	30	23	26	24	118	152		
3	12	17	11	13	14	20	53	217		
4	26	44	22	25	22	20	117	153		
5	39	27	36	27	20	21	129	141		
6	43	34	30	23	27	19	128	142		(As above.)
7	18	18	24	19	7	21	74	196		
8	30	31	21	19	22	20	101	169		
9	25	28	25	22	23	18	100	170		
10	28	24	24	20	27	22	96	174		
Aver...	29	28	25	21	21	20	103	167		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	18	24	34	27	21	28	103	167		
2	47	43	28	20	22	22	138	132		
3	42	51	37	26	25	19	156	114		
4	56	50	25	21	26	21	152	118		
5	49	44	32	30	31	17	155	115		
6	51	43	34	28	26	21	156	114		(As above.)
7	55	49	27	29	29	18	160	110		
8	43	52	36	25	23	20	156	114		
9	17	28	26	44	17	23	115	155		
10	52	57	23	23	24	18	160	110		
Aver...	43	44	30	28	24	21	145	125		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	85	68	34	32	11	13	219	51		
2	116	60	39	21	15	3	236	34		
3	100	65	34	25	12	7	224	46		
4	70	77	49	26	15	12	222	48		
5	100	63	54	28	16	9	245	25		
6	83	72	47	27	20	10	229	41	(As before.)	
7	77	80	51	23	17	7	231	39		
8	43	56	53	30	22	11	182	88		
9	93	67	40	31	18	8	230	40		
10	103	63	44	29	7	10	238	32		
Aver...	87	67	44	27	15	9	226	44		

16-BORE, No. 1801; weight, 5lb. 8½oz.; barrels, 27in.

[With Smaller Charge of Shot.]

RIGHT BARREL, 36grs. powder; ¾oz. of shot (236 pellets); gas pressure, 1·29 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	8	13	15	13	15	21	49	187	1141	22·6
2	11	7	17	16	9	13	51	185	1186	24·2
3	28	34	21	22	17	7	105	131	1172	23·2
4	13	14	10	14	13	17	50	186	1145	23·2
5	19	23	20	17	11	11	79	157	1181	23·8
6	17	31	25	21	15	10	94	142	1154	23·0
7	20	26	27	16	18	19	89	147	1167	23·5
8	16	8	18	14	11	15	56	180	1132	22·8
9	15	19	21	18	16	18	73	163	1172	23·7
10	24	30	26	20	14	12	100	136	1149	23·0
Aver...	17	20	20	17	14	14	75	161	1160	23·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	51	33	24	17	12	168	68		
2	56	44	31	29	10	14	160	76		
3	14	30	26	22	21	19	92	144		
4	54	45	28	21	15	24	148	88		
5	46	36	22	26	18	18	130	106		
6	50	54	28	25	26	20	157	79	(As above.)	
7	47	27	30	29	19	17	133	103		
8	58	54	31	27	14	16	170	66		
9	53	49	27	25	15	14	154	82		
10	54	32	31	27	29	21	144	92		
Aver...	49	42	29	25	18	17	146	90		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	48	42	39	39	16	17	168	68		
2	51	66	34	35	13	4	186	50		
3	93	53	27	18	11	5	191	45		
4	76	50	32	21	18	3	179	57		
5	41	49	43	35	21	10	168	68		
6	36	63	56	32	18	14	187	49	(As above.)	
7	42	57	52	37	10	15	188	48		
8	80	65	37	20	9	6	202	34		
9	47	57	46	24	17	11	174	62		
10	55	52	48	39	19	8	194	42		
Aver...	57	55	41	30	15	9	184	53		

LEFT BARREL, 36grs. powder; ¾oz. of shot (236 pellets); gas pressure, 1·29 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	21	22	28	24	17	16	95	141		
2	29	27	19	20	19	11	95	141		
3	18	20	25	23	18	10	86	150		
4	25	25	17	18	14	19	85	151		
5	20	30	21	17	16	13	88	148		
6	18	19	23	21	20	20	81	155	(As above.)	
7	31	23	18	16	9	12	88	148		
8	16	24	20	19	17	18	79	157		
9	23	19	24	23	23	15	87	149		
10	27	27	23	25	11	7	101	135		
Aver...	23	24	23	20	16	14	88	147		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	35	28	20	18	11	143	93		
2	51	32	31	24	15	16	138	98		
3	63	46	33	22	14	15	164	72		
4	51	55	25	26	20	10	157	79		
5	54	34	39	19	18	12	146	90		
6	58	51	32	25	16	13	166	70	(As before.)	
7	46	38	25	29	21	17	138	98		
8	59	29	15	22	17	16	125	111		
9	66	31	27	24	15	14	148	88		
10	37	27	16	14	19	14	94	142		
Aver...	54	38	27	22	17	14	142	94		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	100	48	39	19	12	4	206	30		
2	80	55	30	22	8	11	187	49		
3	97	60	36	21	3	9	214	22		
4	95	63	35	17	16	1	210	26		
5	108	58	38	13	5	3	217	19		
6	45	52	37	28	15	15	162	74	(As above.	
7	120	52	26	18	13	12	216	20		
8	88	66	39	20	14	7	213	23		
9	103	66	24	17	9	4	210	26		
10	101	44	33	28	12	10	206	30		
Aver...	94	56	34	20	11	8	204	32		

("*Field*," *April* 4, 1896; *Vol.* 87, *p.* 496.)

THE RESULTS OBTAINED in these trials appear to us to increase in interest as they go on; and they likewise show that the additional trouble caused by half a dozen rings upon the target is not labour thrown away. The records thus obtained supply definite information bearing on various moot points which are frequently discussed, but whereon discussion alone is often unable to arrive at any satisfactory conclusion; while the ordinary method of recording target experiments, by stating merely the total number of pellets in a circle of 30 inches diameter, frequently provides only a scant supply of explicit details, and occasionally leads to inferences that are quite erroneous.

One of the points often discussed is that which relates to the comparative patterns of chokebores and cylinders. A few years ago there was a great rush in favour of chokebores, and some people had both barrels heavily choked. The result was that many birds fired at at short distances were "clean missed," and those which were hit were "stuffed with lead." A reaction naturally ensued; disappointed sportsmen thereupon had the choke taken out of their barrels, and many went back to cylinders pure and simple. Others, more cautious, had but one barrel altered to the cylinder, while the second either remained as before, or was reduced from a full to a medium choke. At the present time we believe this to be the more generally adopted practice—a pattern from 120 to 130 pellets in the 30in. circle at 40 yards, with 1¼oz. of No. 6, when fired from the first barrel, and from 160 to 180 pellets when fired from the second barrel, being ordinarily chosen. But how many people are there who ascertain what their guns really do when fired at shorter distances than 40 yards? Or, if they substitute 1oz. or ¾oz. for 1¼oz., what do they know as to how the alteration of charge affects the shooting of the gun?

With some guns, a reduction in the charge of shot fired will be followed very closely by a corresponding reduction in the number of pellets placed in the circle. Thus if 1oz. be used, instead of 1¼oz., there would be about one-ninth fewer pellets; or if ¾oz. be used instead of 1oz., the pattern would be lessened by about one-eighth. But different guns have their idiosyncrasies; and while some may show rather less than the proportionate reduction of pattern, others may increase or fall off considerably in the number of pellets placed in the 30in. circle when the charge is altered.

The following table will show how guns tested in the present trial have behaved in this respect. (In the 12-bore No. 5466 the right

barrel gives rather the larger pattern, its owner firing the left barrel first.)

12-Bores.

Gun. Number.	With 1oz. of Shot. Patterns of Barrels. Right.	Left.	With ¾oz. of Shot. Right Pattern. Relative.	Actual.	Left Pattern. Relative.	Actual.
5466 ...	123	115	108 ...	110	101 ...	106
1906 ...	106	170	93 ...	95	149 ...	140
2052 ...	109	141	96 ...	105	123 ...	123

16-Bores.

854 ...	163	157	143 ...	146	137 ...	137
1801 ...	103	103	90 ...	75	90 ...	88
3794 ...	110	121	96 ...	103	106 ...	111

20-Bores.

6330 ...	121	118	115 ...	140	103 ...	141

From these figures it will be observed that, in the majority of instances, the actual patterns with the ¾oz. charge of shot came very close to the relative proportion that should have been given in comparison with the 1oz. charge. But the 20-bore made a much larger pattern with the smaller charge of shot; and it also performed more regularly from round to round, thereby demonstrating that the 1oz. charge was unsuited to this gun.

And with 16-bore No. 1801 there was another marked exception; for, although the left barrel came nearly up to its due proportion, the right barrel was fully 17 per cent. below par; and a reference to the table of results previously given will show how remarkably irregular were the patterns. With the 1oz. charge they were not very good; but with ¾oz. they were much worse. We here repeat three successive rounds with the latter charge:

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.
1	8	13	15	13	15	21
2	11	7	17	16	9	13
3	28	34	21	22	17	7

It becomes obvious at a glance, that if, in the very centre of the target, there are only eight pellets in a circle which is 15 inches in diameter, or 225 in area, the chances of killing a bird are somewhat remote. And it is very curious to note that, at the extreme edge of the target, where the circle is rather over 36 inches in diameter, the pellets of the same round are nearly three times as numerous as they are in the centre.

Another purpose served by the division of the target is to show the relative distribution of pellets with different kinds of boring. With one of the 12-bores previously tried [No. 1906], the total number of pellets in the 30 inch circle at 20 yards varies but little with the two barrels—the right being 226 and the left 239. Such being the case, one might possibly assume, on first hearing this fact mentioned, that the choked pattern would be nearly as open as that of the cylinder. But here once more comes in the advantage of the rings upon the target; for, on comparing the records of the various rings, the distribution of the respective patterns is found to be as follows:

No. 1906, 12-bore:	1st ring.	2nd ring.	3rd ring.	4th ring.	Total. 30in.	Killing circle.
Cylinder at 20 yards ...	99 ...	68 ...	37 ...	22 =	226	30in.
Choke ditto	166 ...	49 ...	16 ...	8 =	239	26in.

It is evident that the left barrel, which places two-thirds of the 30 inch pattern within one-fourth of the area of the circle, is not a very desirable one for shooting game at 20 yards. But then, on the other hand, people do not, as a rule, want to use the choked barrel at 20 yards; they ordinarily prefer to reserve that barrel for longer distances. And if the cylinder is fired at 20 yards and the choke at 30 yards, the patterns become very nearly on an equality as regards the distribution of the charge, as will be seen by the following records of the two barrels of the same gun:

No. 1906, 12 bore:	1st ring.	2nd ring.	3rd ring.	4th ring.	30 inch Pattern.	Killing circle.
Cylinder at 20 yards ...	99 ...	68 ...	37 ...	22 =	226	3 in.
Choke at 30 yards	92 ...	58 ...	33 ...	26 =	214	30in.
Cylinder at 30 yards ...	57 ...	44 ...	33 ...	26 =	160	3 in.
Choke at 40 yards	64 ...	49 ...	32 ...	25 =	170	36in.

Here is a similar comparative record with another 12-bore, in which the patterns of the choked barrel at 30 and 40 yards respectively accord even more closely with those of the cylinder at 10 yards less distance:

No. 2502, 12-bore:	1st ring.	2nd ring.	3rd ring.	4th ring.	30 inch Pattern.	Killing circle.
Cylinder at 20 yards ...	85 ...	65 ...	39 ...	23 =	212	30in.
Choke at 30 yards	103 ...	55 ...	32 ...	22 =	212	30in.
Cylinder at 30 yards ...	50 ...	43 ...	36 ...	18 =	147	33in.
Choke at 40 yards	50 ...	37 ...	30 ...	24 =	141	33in.

And results very similar to these would be likely to occur at longer ranges.

In contradistinction to the above we give the averages of another 12-bore, in which the two barrels are nearly alike, but, as mentioned above, the owner uses the left as his first barrel.

No. 5466, 12-bore:	1st ring.	2nd ring.	3rd ring.	4th ring.	Total 30in.	Killing circle.
First, at 20 yards.....	98 ...	60 ...	34 ...	24 =	216	30in.
Second, ditto.....	109 ...	56 ...	34 ...	32 =	231	30in.
First, at 30 yards.....	77 ...	54 ...	35 ...	26 =	192	36in.
Second, ditto.....	58 ...	48 ...	34 ...	29 =	169	33in.
First, at 40 yards.....	39 ...	32 ...	24 ...	20 =	115	36in.
Second, ditto.....	37 ...	33 ...	28 ...	25 =	123	36in.

Anyone who wishes to see how the two barrels compare at different ranges may take the first line at 20 yards and put it in comparison with the second line at 30 yards; or take the first at 30, and compare it with the second at 40 yards.

The next gun is a 16-bore with both barrels choked. The average distribution of pattern at the three ranges was as follows:

No. 854, 16-bore:	1st ring.	2nd ring.	3rd ring.	4th ring.	30 inch Pattern.	Killing circle.
At 20 yards	140 ...	50 ...	23 ...	11 =	223	26in.
,, 30 ,, ...	84 ...	57 ...	35 ...	25 =	201	33in.
,, 40 ,, ...	59 ...	45 ...	32 ...	24 =	160	36in.

The barrels of 12-bore No. 1906, which placed 166 pellets within the first ring at 20 yards, are only 24 inches in length: and the pellets in that ring exceed even the number put in the same ring by 16-bore No. 854; yet at 40 yards the pattern with the two guns is nearly the same. The 12-bore, however, has barrels four inches shorter than the 16-bore.

The last is a 20-bore, with both barrels choked; and here we give the average distribution of pattern at the three ranges with both charges.

No. 6330, 20-bore:	1st ring.	2nd ring.	3rd ring.	4th ring.	30 inch Pattern.	Killing circle.
20 yards—1oz.	181 ...	44 ...	17 ...	8 =	250	26in.
,, ¾oz.	143 ...	39 ...	18 ...	11 =	211	26in.
30 yards—1oz.	79 ...	40 ...	37 ...	22 =	182	33in.
,, ¾oz.	85 ...	47 ...	30 ...	19 =	181	30in.
40 yards—1oz.	44 ...	34 ...	26 ...	20 =	124	36in.
,, ¾oz.	53 ...	38 ...	28 ...	21 =	140	33in.

20-BORE, No. 6330; weight, 5lb. 4½oz.; barrels, 28in.

RIGHT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·03 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1 ...	45 ...	28 ...	28 ...	25	18 ...	21	126 ...	144	1163 ...	29·1
2 ...	52 ...	46 ...	26 ...	21	14 ...	11	145 ...	125	1181 ...	29·3
3 ...	70 ...	58 ...	32 ...	25	13 ...	13	185 ...	85	1145 ...	28·5
4 ...	49 ...	38 ...	30 ...	27	14 ...	18	144 ...	126	1149 ...	27·6
5 ...	42 ...	31 ...	34 ...	20	13 ...	21	127 ...	143	1181 ...	30·0
6 ...	25 ...	26 ...	24 ...	14	18 ...	14	99 ...	181	1141 ...	28·0
7 ...	41 ...	32 ...	25 ...	22	26 ...	11	120 ...	150	1235 ...	33·7
8 ...	56 ...	60 ...	36 ...	24	20 ...	10	176 ...	94	1167 ...	28·8
9 ...	29 ...	19 ...	19 ...	11	17 ...	13	78 ...	192	1220 ...	30·4
10 ...	47 ...	35 ...	23 ...	19	15 ...	17	123 ...	147	1136 ...	27·4
Aver...	45 ...	37 ...	28 ...	21	17 ...	15	131 ...	139	1173 ...	29·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1 ...	84 ...	66 ...	38 ...	14	15 ...	17	202 ...	68		
2 ...	58 ...	51 ...	40 ...	29	12 ...	15	178 ...	92		
3 ...	56 ...	35 ...	35 ...	21	12 ...	10	147 ...	123		
4 ...	77	40 ...	33	22	19 ...	13	172 ...	98		
5 ...	83 ...	48 ...	31 ...	24	17 ...	10	186 ...	84		
6 ...	51 ...	38 ...	33 ...	26	15 ...	16	151 ...	119	(As above.)	
7 ...	80 ...	55 ...	31 ...	20	13 ...	9	186 ...	84		
8 ...	52 ...	47 ...	39 ...	35	13 ...	19	173 ...	97		
9 ...	61 ...	44 ...	31 ...	31	19 ...	12	166 ...	104		
10 ...	65 ...	63 ...	34 ...	23	11 ...	15	184 ...	86		
Aver...	66 ...	49 ...	35 ...	24	15 ...	14	174 ...	96		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	176	35	15	7	0	2	233	37		
2	199	42	20	5	0	1	266	4		
3	185	30	13	10	7	3	238	32		
4	207	38	10	5	2	1	260	10		
5	183	48	14	8	10	0	252	18		
6	201	35	18	5	0	0	259	11	(As before.)	
7	175	44	7	8	4	5	234	36		
8	186	41	8	4	0	0	239	31		
9	200	39	17	5	5	0	261	9		
10	140	50	36	20	13	8	246	24		
Aver.	185	40	16	8	4	2	249	21		

LEFT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·08 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	20	16	11	21	11	13	66	202		
2	55	32	28	19	18	16	134	136		
3	22	19	14	10	10	6	65	205		
4	38	27	20	23	14	17	107	163		
5	51	34	23	26	21	15	134	136		
6	54	40	22	19	19	12	135	135	(As above.)	
7	47	48	25	21	21	24	136	134		
8	43	31	26	18	20	18	118	152		
9	51	38	31	15	16	17	135	135		
10	57	32	26	25	15	15	140	130		
Aver.	44	31	23	20	16	15	118	152		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	53	46	33	20	21	16	151	119		
2	95	48	41	19	17	10	208	67		
3	83	52	37	24	15	19	195	75		
4	84	43	35	23	18	11	184	86		
5	79	50	42	18	12	13	189	81		
6	88	51	46	26	19	11	211	59	(As above.)	
7	97	59	38	17	17	5	211	59		
8	76	43	45	22	23	13	186	84		
9	88	51	30	24	17	26	196	77		
10	80	46	39	21	20	14	186	84		
Aver.	82	49	39	21	18	14	191	79		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	181	49	16	10	1	4	256	14		
2	168	41	23	7	4	4	239	31		
3	196	50	12	1	1	0	259	11		
4	177	47	21	11	5	1	256	14		
5	173	59	13	5	5	2	249	21		
6	180	40	15	8	6	5	243	27		
7	189	41	18	10	2	1	258	12		
8	165	55	22	9	5	2	251	19		
9	183	43	17	12	3	0	258	15		
10	170	56	20	6	4	3	259	18		
Aver.	178	48	18	7	4	2	251	19		

20-BORE, No. 6330; weight, 5lb. 5½oz.; barrels, 26in.

[WITH SMALLER CHARGE.]

RIGHT BARREL, 35grs. powder; ¾oz. of shot (236 pellets); gas pressure, 2·41 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	53	44	26	17	17	13	140	96	1195	24·7
2	60	25	22	26	15	15	133	108	1181	23·5
3	63	29	25	17	19	18	134	102	1186	24·4
4	45	47	26	30	20	17	158	78	1145	22·5
5	54	32	31	20	21	12	137	99	1163	23·7
6	48	41	25	19	16	17	133	103	1172	23·0
7	52	30	23	31	18	14	136	100	1132	22·1
8	59	27	32	25	16	13	143	93	1167	22·8
9	54	33	29	23	21	18	138	98	1190	24·3
10	56	40	29	20	20	19	145	91	1141	22·6
Aver.	54	35	28	23	18	16	140	96	1167	23·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	84	47	37	15	7	7	183	53		
2	95	58	22	18	10	10	193	43		
3	80	44	28	21	12	11	173	63		
4	72	38	31	24	17	9	165	71		
5	75	35	33	22	15	10	165	71		
6	89	49	29	21	11	6	183	43	(As before.)	
7	83	40	33	16	8	10	172	64		
8	91	53	23	19	9	8	186	50		
9	85	51	30	19	10	7	185	51		
10	77	42	35	20	14	11	174	62		
Aver.	83	46	30	19	11	9	178	58		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	148	40	9	0	1	2	197	39		
2	150	46	14	10	9	3	220	16		
3	145	41	15	2	4	2	208	33		
4	151	35	17	6	7	0	209	27		
5	128	50	24	15	8	6	217	19		
6	156	37	18	4	5	0	215	21	(As above.)	
7	147	38	16	12	2	1	213	23		
8	144	44	22	8	6	5	218	18		
9	134	32	17	11	5	3	194	42		
10	130	51	20	14	7	0	215	21		
Aver.	143	41	17	8	5	2	209	27		

LEFT BARREL, 35grs. powder; ¾oz. of shot (236 pellets); gas pressure, 2·41 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30 n circle.	Outside 30in.	Velocity.	Recoil.
1	47	49	29	22	8	13	147	89		
2	50	46	24	19	15	9	139	97		
3	72	50	26	6	9	16	154	82		
4	43	37	27	24	13	12	131	105		
5	48	32	30	19	18	18	129	107		
6	62	48	21	16	11	11	147	89	(As above.)	
7	48	34	26	23	16	10	131	105		
8	51	45	33	21	17	12	150	86		
9	49	38	31	23	13	16	141	95		
10	46	41	29	18	12	14	134	102		
Aver.	52	42	28	19	13	13	141	95		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	91	43	30	11	5	11	174	62		
2	94	44	35	20	11	9	193	43		
3	81	56	32	23	13	11	192	44		
4	90	50	26	21	15	10	187	49		
5	95	52	22	17	9	6	196	50		
6	108	48	25	13	7	11	194	42	(As above.)	
7	86	55	31	19	12	7	191	45		
8	47	50	28	30	20	10	155	81		
9	101	43	27	16	13	12	187	49		
10	82	47	33	24	11	9	186	50		
Aver.	87	49	29	19	12	10	184	57		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	151	39	19	14	1	2	223	13		
2	145	33	20	16	7	0	217	19		
3	142	40	18	7	7	5	207	29		
4	152	30	11	5	4	1	198	38		
5	132	41	23	22	13	5	218	18		
6	140	39	16	18	9	4	213	23	(As above.)	
7	154	34	12	5	0	0	205	31		
8	146	40	17	9	5	3	212	24		
9	131	42	21	20	7	2	214	22		
10	139	37	23	23	6	4	232	14		
Aver.	143	38	18	14	6	3	213	23		

16-BORE, No. 3794; weight, 5lb. 5½oz.; barrels, 28in.

RIGHT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 2·51 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	23	34	20	23	17	23	100	170	1186	29·4
2	40	32	25	21	19	16	118	153	1145	28·0
3	28	24	24	23	11	15	99	171	1195	29·7
4	32	27	26	24	18	17	109	161	1172	28·6
5	34	35	28	18	20	15	110	160	1149	28·1
6	39	31	34	21	18	19	125	145	1186	29·6
7	25	29	28	19	18	17	101	169	1128	27·7
8	44	34	39	22	17	14	139	131	1167	28·0
9	30	25	27	20	15	18	103	168	1136	27·8
10	21	44	21	11	20	14	97	173	1132	27·6
Aver...	32	31	27	20	17	17	110	160	1160	28·4

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	45	56	29	25	18	28	155	115		
2	53	50	28	23	22	17	154	116		
3	56	40	36	22	17	24	154	116		
4	49	38	27	25	20	16	139	131		
5	40	55	31	20	17	18	146	124		
6	68	53	33	27	25	11	175	95	(As above.)	
7	47	38	29	26	18	14	140	130		
8	55	41	38	24	24	20	158	112		
9	28	26	29	30	21	19	113	157		
10	36	40	31	24	18	25	131	139		
Aver...	47	44	31	25	20	19	147	123		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	106	50	32	32	10	12	220	50		
2	102	58	34	21	9	4	215	55		
3	125	60	20	19	11	9	224	46		
4	104	57	32	11	14	11	204	66		
5	121	52	28	16	12	10	217	53		
6	130	56	16	10	9	4	212	58	(As above.)	
7	118	50	30	21	7	7	219	51		
8	127	65	35	19	8	5	246	24		
9	110	67	27	15	10	3	219	51		
10	98	58	37	17	9	8	210	60		
Aver...	114	57	29	18	10	7	218	52		

LEFT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 2·51 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	57	40	21	19	16	15	137	133		
2	48	29	24	24	20	17	125	145		
3	39	36	26	18	15	21	119	151		
4	42	41	23	20	18	13	126	144		
5	51	37	22	15	14	15	125	145		
6	36	33	29	17	21	18	114	156	(As above.)	
7	34	31	23	22	24	21	110	160		
8	46	26	25	19	23	19	116	154		
9	49	25	28	20	16	12	122	148		
10	37	30	21	23	16	19	111	159		
Aver..	44	32	24	20	18	17	121	149		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	25	32	20	25	21	24	102	168		
2	58	50	36	22	20	13	166	114		
3	60	51	31	24	17	16	175	95		
4	54	39	27	20	19	18	140	130		
5	60	53	38	26	23	14	177	93	(As above.)	
6	52	41	31	19	18	17	143	127		
7	21	28	16	24	23	21	89	181		
8	67	48	32	21	22	18	168	102		
9	34	25	29	24	20	32	113	158		
10	51	43	27	17	17	19	138	132		
Aver...	49	41	29	22	20	18	141	129		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	41	57	49	29	21	11	176	94		
2	119	60	35	19	13	0	233	87		
3	53	61	55	26	16	12	195	75		
4	97	53	32	24	8	7	206	64		
5	123	70	22	17	9	0	231	39		
6	106	54	44	20	12	3	224	46	(As before.)	
7	117	59	31	25	5	6	232	88		
8	83	62	50	27	11	3	221	49		
9	120	58	37	18	6	4	233	87		
10	121	71	38	13	7	5	243	27		
Aver...	98	60	39	22	11	5	219	51		

16-BORE, No. 3794; weight, 5lb. 5½oz.; barrels, 28in.

[With Smaller Charge of Shot.]

RIGHT BARREL, 35grs. powder; ⅞oz. of shot (236 pellets); gas pressure, 1·21 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft.lb.
1	34	25	20	21	18	18	100	136	1186	24·8
2	24	27	24	20	15	13	95	141	1186	25·0
3	27	29	25	24	18	14	105	131	1163	24·6
4	29	26	28	21	19	17	104	132	1172	24·7
5	26	20	22	25	22	9	93	143	1154	23·6
6	30	27	27	23	18	8	106	130	1132	22·8
7	25	28	29	20	14	10	102	134	1136	23·0
8	31	21	25	23	20	16	100	136	1172	24·5
9	32	24	24	19	16	11	99	137	1145	23·0
10	28	30	26	25	14	11	109	127	1158	23·8
Aver...	29	26	25	22	17	13	102	134	1160	24·0

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	52	49	37	28	10	16	166	70		
2	48	40	29	23	18	14	140	96		
3	43	37	35	32	23	16	147	89		
4	44	42	36	35	26	18	157	79		
5	25	28	27	30	19	20	110	126		
6	41	39	30	27	20	19	137	99	(As above.)	
7	46	50	31	30	16	17	157	79		
8	44	41	32	25	13	8	142	94		
9	50	46	34	23	15	10	153	83		
10	46	35	20	25	30	32	126	110		
Aver...	44	41	31	28	19	17	144	92		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	109	54	26	16	9	4	205	31		
2	94	63	29	22	7	9	207	29		
3	80	53	31	19	11	6	183	53		
4	106	48	18	16	18	9	188	48		
5	90	61	21	14	7	3	186	50		
6	73	40	27	23	14	11	163	74	(As above.)	
7	102	51	20	17	12	5	190	46		
8	99	57	33	18	9	5	207	29		
9	83	49	25	20	10	8	176	60		
10	101	66	38	12	5	3	217	19		
Aver...	94	54	27	18	10	5	193	43		

LEFT BARREL, 35grs. powder; ⅞oz. of shot (236 pellets); gas pressure, 1·21 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	26	18	16	19	23	13	79	157		
2	41	31	28	28	20	15	122	114		
3	36	34	26	11	16	22	107	129		
4	35	27	24	15	15	14	101	135		
5	37	20	20	17	14	12	94	142		
6	33	36	30	25	17	11	124	112	(As above.)	
7	38	31	19	16	18	13	104	132		
8	30	28	27	18	21	17	103	133		
9	44	39	31	29	17	10	143	93		
10	39	32	35	20	19	20	126	110		
Aver...	36	30	26	19	18	15	111	125		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	52	40	30	22	16	16	144	92		
2	61	37	35	29	18	14	162	74		
3	46	44	32	24	11	19	146	90		
4	59	41	28	31	20	11	159	77		
5	76	40	24	25	15	17	165	71		
6	66	32	25	20	13	15	143	93	(As before.)	
7	61	43	38	25	15	12	167	69		
8	58	35	37	32	16	10	162	74		
9	64	37	26	20	19	16	147	89		
10	56	51	26	33	15	19	166	70		
Aver.	60	40	30	26	16	15	156	80		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	84	68	31	16	13	8	199	37		
2	100	61	29	20	5	2	210	26		
3	115	56	34	17	4	0	222	14		
4	91	49	28	18	11	7	181	55		
5	118	68	25	10	6	2	216	20		
6	97	59	31	18	9	4	205	31	(As above.)	
7	119	56	26	17	7	1	218	18		
8	108	60	31	11	8	0	205	31		
9	98	48	22	19	15	6	181	55		
10	110	55	30	15	13	2	210	26		
Aver.	108	57	29	16	9	3	205	31		

("*Field*," *April* 11, 1896; *Vol* 87, *p.* 539.)

AN EXAMINATION OF THE RECORDS given in our last article elicits some rather curious results. In a previous issue we pointed out that in ten rounds on the first day, with the same gun, and with accurately loaded cartridges, there was a difference of more than 40 ft.sec. in velocity and of several foot-pounds in the registered amount of recoil; and the only conclusion we could come to as regards the cause of these differences was that there must have been a variation in the strength of the percussion caps; for whereas all other conditions with respect to the contents of the cartridges were distinctly ascertained, nothing could be known as to the amount of detonating composition contained in the respective caps.

The gun whose records we then examined was a 12-bore—the first one tried; and it might possibly be imagined that these variations were exceptional. Such, however, does not appear to have been the case; for the other guns have since shown variations of a similar kind, and some of them in much greater degree, probably owing to the guns differing in size of gauge, and weight and length of barrels. The widest extremes, however, that we have yet met with are to be found in the records of the No. 6330 20-bore—a gun that shot admirably on the whole; yet, while its lowest velocity in the ten rounds was 1136 f.s., with 27·4 ft.lb. recoil, another of the ten rounds was very nearly 100 f.s. higher, viz., 1235 f.s., with 33·7 ft.lb. recoil; or, to put it in a different fashion, the last-mentioned round had 8 per cent. greater velocity than the one previously stated, and showed about 23 per cent. more energy of recoil.

Such a remarkable difference between two rounds of the same series appears to us only to be explicable by the supposition that there was a larger amount of detonating composition in the one cap than there was in the other; that there was consequently a quicker ignition of the powder by the strong cap; and that the effects of this more rapid combustion were intensified in the narrow gauge of the 20-bore, where the length of the column of shot would be 1·4, as compared with 1·0 in the 12-bore; while the frictional resistance would increase accordingly, and cause the exhibition of greater explosive force in the powder.

What may be the exact amount of pressure in the gun-chamber produced by the unknown quantity of composition in an abnormally strong cap, must, of course, be also unknown; but the increased amount of stress caused merely by change of gauge, when average caps are used, has been sufficiently demonstrated in the course of these experiments, as will be seen by the following figures:

	12-bore.	16-bore.	20-bore.
36grs. and 1oz.	1·88 tons	—	—
36grs. and 1oz.	—	2·46 tons	3·03 tons.

So that, with 2grs. less powder, and the same charge of shot, the stress in the barrel is vastly increased in the smaller bores, when the records are the average of a series of rounds, and consequently may be taken as representing the average strength of the caps. Hence one may not unnaturally conclude that the increase of force exhibited by the powder, as the size of bore diminishes, may account for the fact that, whereas the difference between the extremes of velocity in three 12-bore guns averaged 43 f.s., the difference in the 20-bores was 87 f.s. on the average, though the second 20-bore tried did not show such wide disparities as the first.

Besides the variations which probably arise from differences in strength of caps, there would appear also to be divergences due to peculiarities in the guns themselves—owing, perhaps, to the nature of the boring, or the length of the barrels, or the thickness and degree of expansiveness of the metal. Old Joe Manton's guns had the reputation of kicking amazingly with the fine-grain powder in vogue at the beginning of the century; and there are some people even in these days who declare that no powder will kill properly unless it also punishes the shoulder. But in the present trials any variations of recoil cannot be due to difference of powder, as the same explosive is used throughout.

The length of the barrels, however, may have some influence; yet with two guns of the same length, though not of equal weight, but using the same charges of powder and shot, there are considerable variations of result; but these will be referred to at greater length when more of the guns have been tried.

Cylinder and Choked Barrels.

We have received the following from a correspondent who wishes for information on this subject:

In the most interesting description of your present experiments with light 12, 16, and 20-bore guns, I cannot ascertain, from your remarks, if they are "choked" or "cylinder." COLONEL.

In some instances [three pages back] we used the words "cylinder at 20 yards," and "choked at 30 yards," together with the number of the gun, where there was such a marked difference in the patterns as would warrant such a distinction; but, in other instances, where the two barrels gave nearly the same results, we merely said "right" or "left" barrel, or "first" and "second" barrel if the owner of the gun had had his gun made to give a rather closer pattern with the right, which he used as his second barrel. It is difficult to lay down any hard-and-fast line as to what is a cylinder and what is a choked barrel. Practically speaking, a truly cylindrical tube is never sent out in a gun; the barrel is always "touched up" in some respects. But it is generally understood that a 12-bore barrel ought not to be classed as a "cylinder" if its average pattern, with 1¼oz. of No. 6 shot, in a 30in. circle at 40 yards, exceeds 180 pellets (which is near about 40 per cent. of the full charge, the remaining 60 per cent being outside the 30in. circle). With the 1oz. charge the corresponding pattern would be about 115, and with the ⅞oz. charge it would be about 100 pellets in the 30in circle.

Taking the numbers here mentioned as representing ordinary cylinder patterns with the charges stated, an extremely full choke might put nearly double as many pellets in the same circle; while the medium or half choke would give about 50 per cent. more than the ordinary cylinder, and the slight or quarter choke about 25 per cent. more. From this point the choke dwindles gradually away, until what is euphemistically termed "a remarkably good cylinder," or "an improved cylinder," may be nothing more than a very slight choke in disguise.

20-BORE, No. 10,132; weight, 5lb. 4¼oz.; barrels, 28in.

RIGHT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure 3·03 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside (10 yards). 30in.	Velocity Ft. sec.	Recoil. Ft lb.
1	34	29	18	25	15	16	106	164	1167	28·3
2	30	31	24	27	19	15	112	158	1176	28·7
3	12	13	13	12	17	20	50	220	1141	27·1
4	36	27	27	18	14	18	108	162	1210	33·0
5	25	34	25	19	21	17	103	167	1172	28·5
6	33	30	21	22	19	16	106	164	1158	27·4
7	30	32	30	19	8	14	111	159	1195	30·0
8	32	29	21	10	20	11	92	178	1136	26·7
9	28	35	33	20	15	17	116	154	1141	27·0
10	36	24	23	18	16	14	101	169	1186	29·3
Aver.	30	28	23	19	16	16	100	170	1168	28·6

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil
1	50	38	22	29	21	19	139	131		
2	45	41	26	25	18	15	137	133		
3	44	28	33	32	16	22	157	133		
4	51	36	30	26	17	14	143	127		
5	33	44	28	21	22	20	135	145		
6	46	39	31	23	19	16	139	131	(As before.)	
7	55	43	32	27	16	19	157	113		
8	53	40	24	20	20	21	137	133		
9	48	47	25	24	18	14	144	126		
10	52	27	33	22	10	22	134	136		
Aver...	48	38	28	25	18	18	139	131		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	84	61	43	27	21	6	214	56		
2	96	55	34	15	12	9	200	70		
3	78	59	43	30	13	8	209	61		
4	110	56	29	26	9	9	221	49		
5	107	49	43	23	17	3	221	49		
6	88	60	35	20	16	10	208	67	(As above.)	
7	100	68	36	19	15	8	233	47		
8	93	51	40	16	17	7	200	70		
9	108	53	38	25	18	10	224	46		
10	115	63	29	21	10	8	228	42		
Aver...	98	57	37	22	15	8	214	56		

20-BORE, No. 10,162; weight, 5lb. 4¼oz.; barrels, 28in.

LEFT BARREL, 36grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·08 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	13	14	11	14	15	15	51	219		
2	30	28	23	18	20	19	99	171		
3	34	33	21	22	19	13	110	160		
4	40	29	29	17	15	11	115	155		
5	27	26	27	21	16	20	101	169	(As above.)	
6	25	31	28	20	18	10	104	166		
7	39	26	19	10	17	19	94	176		
8	28	35	21	19	16	13	103	167		
9	29	25	26	22	19	16	102	168		
10	23	22	15	13	15	9	71	199		
Aver...	29	27	22	17	17	14	95	175		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	45	42	26	24	17	16	137	133		
2	61	37	26	21	20	19	145	125		
3	42	32	27	26	27	22	127	143		
4	50	40	31	21	15	14	142	128		
5	47	33	30	26	14	25	136	134		
6	56	29	28	22	23	17	135	135	(As above.)	
7	48	41	30	23	17	26	142	128		
8	45	31	25	19	18	15	120	150		
9	53	37	29	25	14	16	144	126		
10	68	28	30	22	20	22	148	122		
Aver...	52	35	28	23	18	19	138	133		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity	Recoil.
1	99	67	40	24	11	8	230	40		
2	120	75	33	16	13	6	244	26		
3	115	70	25	19	15	5	239	41		
4	111	60	32	22	12	6	225	45		
5	88	71	36	28	14	7	223	47	(As above.)	
6	131	68	28	17	10	4	244	26		
7	106	55	31	20	9	6	219	58		
8	80	67	45	26	13	12	218	52		
9	123	62	30	18	15	7	233	37		
10	101	69	42	15	8	9	237	43		
Aver...	107	66	34	20	12	7	228	42		

20-BORE, No. 10,162: weight, 5lb. 4¼oz.; barrels, 28in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, 35grs. powder; ¾oz. of shot (236 pellets); gas pressure, 2·41 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	30	30	22	11	18	24	93	143	1205	24·2
2	25	27	24	20	15	12	96	140	1141	22·1
3	34	28	27	16	11	14	105	131	1167	23·0
4	32	35	25	21	17	15	113	123	1158	22·5
5	21	23	20	19	13	17	83	153	1141	22·2
6	40	30	26	16	16	10	112	124	1149	22·3
7	10	22	12	14	11	9	88	78	1176	23·6
8	26	29	28	21	19	13	104	132	1195	24·0
9	42	33	24	18	14	21	117	119	1158	22·7
10	34	33	15	23	17	11	104	132	1154	22·4
Aver...	29	29	22	18	15	15	98	133	1164	22·9

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	53	35	23	21	12	15	131	105		
2	41	40	29	25	20	17	135	101		
3	48	33	27	29	17	19	137	99		
4	45	37	30	21	23	15	133	103		
5	50	32	24	24	16	16	130	106		
6	33	45	25	23	18	20	126	110	(As above.)	
7	52	32	23	27	21	16	134	102		
8	43	35	30	26	15	19	134	102		
9	45	38	24	23	13	18	139	97		
10	25	26	29	19	24	20	99	137		
Aver...	43	35	27	24	18	17	129	107		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	96	53	30	21	17	4	199	87		
2	89	39	38	19	7	9	185	51		
3	104	60	27	19	9	6	210	26		
4	97	64	31	13	7	5	205	31		
5	103	45	34	13	9	6	194	42		
6	106	42	33	20	10	5	201	35	(As above.)	
7	92	57	29	15	6	7	198	42		
8	100	61	32	18	11	9	211	25		
9	85	45	27	15	8	15	173	64		
10	101	50	36	19	12	8	206	30		
Aver...	97	52	32	17	9	7	198	38		

LEFT BARREL, 35grs. powder; ¾oz. of shot (236 pellets); gas pressure, 2·41 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	26	21	20	17	19	15	84	152		
2	30	18	18	23	14	18	89	147		
3	36	20	15	15	19	17	86	150		
4	39	23	21	19	15	16	108	134		
5	23	20	17	22	12	13	81	155		
6	28	24	23	18	17	15	96	143	(As above.)	
7	45	26	26	21	18	10	118	118		
8	25	27	22	15	10	21	89	147		
9	35	25	19	20	16	18	99	137		
10	26	19	16	28	10	14	89	147		
Aver...	31	22	20	20	15	15	98	143		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	34	34	30	33	27	13	131	105		
2	60	38	35	21	18	13	154	82		
3	53	43	27	23	17	16	144	92		
4	49	41	30	28	20	9	148	88		
5	45	47	26	26	17	21	144	92		
6	57	39	33	30	19	10	159	77	(As above.)	
7	43	45	29	25	21	15	148	94		
8	63	40	33	33	14	13	166	70		
9	39	36	22	19	18	14	116	120		
10	46	38	31	29	15	8	144	92		
Aver...	49	40	30	26	19	13	145	91		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	110	58	31	19	10	9	219	24		
2	96	60	34	15	14	4	207	29		
3	94	51	33	18	12	7	186	50		
4	96	63	27	17	3	5	203	33		
5	101	55	28	14	6	3	198	38		
6	107	62	30	11	8	8	210	26		(As before.)
7	89	63	36	16	11	6	204	32		
8	93	57	25	20	17	5	184	52		
9	113	45	32	18	10	6	208	28		
10	93	61	37	15	6	4	206	30		
Aver...	97	57	32	16	10	6	209	34		

12-BORE, No. 1072; weight, 5lb. 12½oz.; barrels, 26in.

RIGHT BARREL, 39grs. powder; 1oz. of shot (270 pellets); gas pressure, 1·52 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Ft. sec.	Recoil. Ft. lb.
1	29	16	27	19	15	21	91	179	1205	29·0
2	36	25	23	24	17	18	108	163	1145	26·8
3	49	31	37	19	11	22	136	134	1220	30·0
4	37	28	22	20	19	16	107	163	1176	28·8
5	26	34	30	18	23	10	108	163	1163	28·0
6	42	33	28	20	16	19	123	147	1158	27·6
7	29	22	24	16	11	18	91	179	1176	28·4
8	35	24	22	19	12	22	100	170	1136	27·0
9	38	30	33	17	20	19	118	152	1195	29·0
10	47	32	20	26	14	26	125	145	1163	28·2
Aver...	37	27	27	20	16	19	111	159	1174	28·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	61	52	39	33	25	16	185	85		
2	54	37	35	25	22	14	151	119		
3	63	41	44	19	18	13	167	103		
4	49	36	30	27	20	15	143	128		
5	52	58	36	34	23	15	180	90		
6	58	53	41	32	24	12	184	86		(As above.)
7	50	48	50	29	28	13	177	93		
8	61	42	42	20	17	14	165	105		
9	44	29	33	23	18	22	139	141		
10	60	40	44	32	21	11	176	94		
Aver...	55	44	40	27	22	15	166	104		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	132	63	27	18	6	5	240	30		
2	110	55	40	17	8	4	222	48		
3	120	60	38	15	7	6	233	37		
4	102	69	32	30	10	10	233	37		
5	116	59	29	22	13	8	236	44		
6	115	65	28	11	9	2	219	51		(As above.)
7	100	62	33	18	11	7	195	75		
8	121	68	30	19	8	3	238	32		
9	109	58	35	28	10	5	230	40		
10	97	61	41	25	7	2	224	46		
Aver...	112	62	33	20	9	5	227	43		

LEFT BARREL, 39grs. powder; 1oz. of shot (270 pellets); gas pressure, 1·52 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	40	25	31	15	22	25	111	159		
2	23	31	24	26	24	14	103	167		
3	12	13	12	13	8	14	50	220		
4	39	35	33	24	19	20	131	139		
5	11	17	10	16	11	10	54	216		
6	46	22	27	19	22	17	114	156		(As above.)
7	34	23	19	18	23	16	99	171		
8	30	35	24	20	21	14	109	161		
9	45	27	21	23	18	20	116	154		
10	38	31	25	22	20	12	116	154		
Aver...	31	26	23	20	19	16	100	170		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	59	42	37	31	22	15	169	101		
2	55	41	35	28	24	16	159	111		
3	70	53	32	30	11	22	185	85		
4	51	46	30	26	20	18	153	117		
5	62	35	29	32	18	14	158	112		
6	55	42	32	27	21	17	156	114		(As before.)
7	58	39	30	30	25	24	157	113		
8	60	47	38	36	23	13	181	89		
9	53	50	35	24	20	19	169	106		
10	63	52	41	27	22	16	183	87		
Aver...	58	45	34	29	21	18	166	104		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	125	61	31	15	8	8	232	38		
2	91	55	40	25	11	7	211	59		
3	130	68	28	13	2	3	239	31		
4	93	63	23	18	5	2	195	75		
5	88	56	63	33	9	9	240	30		
6	100	68	35	27	4	5	230	40		(As above.)
7	97	55	25	18	6	3	195	75		
8	104	49	37	22	9	3	212	58		
9	83	53	36	17	7	6	198	77		
10	95	64	38	29	10	14	226	44		
Aver...	100	59	36	22	7	6	217	53		

12-BORE, No. 1072; weight 5lb. 12½oz.; barrels, 26in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, 38grs. powder; ⅞oz. of shot (286 pellets); gas pressure, 1·43 tons per sq. in.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity. Ft.sec.	Recoil. Ft.lb.
1	46	29	27	20	18	11	122	114	1154	22·9
2	32	31	24	17	11	14	104	182	1186	23·8
3	40	31	21	18	27	18	110	126	1195	24·3
4	15	17	14	19	14	7	65	171	1124	23·0
5	53	37	36	21	17	19	147	89	1176	23·6
6	39	32	21	18	14	17	110	126	1154	23·1
7	35	30	33	23	20	15	119	117	1195	24·0
8	43	25	29	20	14	16	117	119	1167	23·4
9	33	33	23	24	11	13	118	123	1136	22·5
10	50	34	30	17	16	15	131	105	1190	24·0
Aver...	39	30	25	20	16	14	114	122	1168	23·4

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	29	26	15	17	24	18	87	149		
2	65	50	45	15	18	10	175	61		
3	78	44	32	24	16	11	178	58		
4	50	48	35	21	18	16	154	82		
5	49	40	33	18	15	15	145	91		
6	73	43	36	15	12	9	166	70		(As above.)
7	53	33	29	26	19	15	141	95		
8	66	36	30	22	18	10	154	82		
9	53	43	42	14	14	18	152	84		
10	53	46	31	18	16	13	177	59		
Aver...	60	41	33	19	16	13	153	83		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	105	53	24	17	15	7	199	37		
2	99	50	43	14	9	3	205	31		
3	111	58	26	23	6	4	217	19		
4	85	61	33	16	12	9	194	42		
5	78	50	53	21	10	3	201	35		
6	113	56	31	15	5	4	215	21		(As above).
7	109	53	23	10	11	6	194	42		
8	75	53	40	18	11	8	186	50		
9	101	49	33	20	8	5	208	28		
10	109	37	34	9	6	8	209	27		
Aver...	98	54	34	16	9	6	208	34		

LEFT BARREL; 33grs. powder; 1oz. of shot (286 pellets); gas pressure 1·43 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle	Outside 30in.	Velocity.	Recoil.
1	38	29	24	21	19	11	112	124		
2	29	33	23	25	12	13	108	128		
3	35	30	23	23	20	14	110	126		
4	43	33	19	19	18	12	113	123		
5	10	10	15	12	10	19	47	189		
6	29	37	33	20	20	17	124	112	(As before.)	
7	31	33	28	23	18	18	115	121		
8	40	31	20	18	16	15	109	127		
9	20	21	18	20	10	11	79	157		
10	34	27	27	23	17	13	110	126		
Aver...	31	28	23	20	16	14	102	134		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	41	30	20	29	10	151	85		
2	49	36	37	23	15	15	150	86		
	71	33	34	23	21	16	166	70		
4	67	45	26	27	16	8	165	71		
5	58	40	34	18	20	12	150	86		
6	65	33	29	21	18	10	148	88	(As above.)	
7	48	34	33	24	23	15	144	92		
8	54	41	35	18	14	17	148	88		
9	69	39	31	22	23	14	161	75		
10	50	42	27	25	19	13	144	92		
Aver...	59	39	32	23	20	13	153	83		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	127	52	17	12	8	4	208	28		
2	98	60	25	18	7	3	201	35		
3	41	65	38	42	18	6	186	50		
4	103	54	31	16	4	2	203	33		
5	93	47	34	23	5	3	197	39		
6	123	50	22	18	6	5	212	24	(As above.)	
7	114	58	33	11	2	1	221	15		
8	106	55	28	19	9	3	208	28		
9	95	66	30	21	10	0	212	24		
10	87	42	37	14	4	3	180	56		
Aver...	98	55	30	19	7	3	203	34		

("*Field*," *April* 18, 1896; *Vol.* 87, *p.* 577.)

A CORRESPONDENT makes the following suggestion in a letter which we just received:

SIR,—I venture to make the suggestion that you should publish the performance of a 12-bore gun, choke and cylinder, of 7lb. weight, loaded with standard loads, in order that your readers who are interested in the present trial of light 12, 16, and 20 bores may have a chance of comparing their respective killing circles, &c. I trust you will see your way to further oblige many of us who are much indebted to you for the trouble you have already taken. GREEN EAGLE.

We will endeavour to carry out our correspondent's suggestion eventually. Meanwhile, we may, by turning back to reports of previous experiments, be able to afford some little information bearing on the question at issue. About seven years ago we carried out some investigations with the purpose of tracing the spread of the shot charge, with cylinders and chokebores, from the muzzle of the gun to the distance of 40 yards. The following figures will show what the patterns were with a 7lb. 12-bore and 1¼oz. of shot, when the size of the circle was increased *pari passu* with the distance from the target. Thus, at 20 yards the gun was fired at a 20 inch circle, at 22 yards it was a 22 inch circle, and so on. Omitting those where the range was less than 20 yards, we commence at that distance with the 20 inch circle.

Yards and Inches.	Cylinder Patterns.	Chokebore Patterns.	Yards and Inches.	Cylinder Patterns.	Chokebore Patterns.
20	183	265	32	183	253
22	188	270	34	187	250
24	183	262	36	179	259
26	189	266	38	175	248
28	182	258	40	170	250
30	181	255			
			Averages...	180	258

The average for distances under 20 yards was 183 with the cylinder and 275 with the choke.

It will be seen that the increase in the size of the circle corresponded very closely with the increase of distance. If one-third be taken off the average cylinder pattern, it will give 120, or the ordinary average with a fair cylinder gun in a 30 inch circle at 40 yards; and if a third be taken off the choke pattern, the average of a fair medium choke will be obtained. On the other hand, if one-third be added to the diameter of the respective circles, a rough idea will be given of the killing circle of the choked barrel; while that of the cylinder may be left unaltered.

20-BORE, No. 1043; weight, 5lb. 10oz.; barrels, 27in.

RIGHT BARREL, 33grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·13 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	29	37	22	19	18	10	107	168	1210	29·0
2	24	21	15	15	21	18	75	195	1167	28·0
3	31	30	37	26	19	11	114	156	1195	29·2
4	30	26	24	23	17	19	108	167	1172	28·0
5	29	23	18	27	14	12	97	173	1173	28·3
6	27	35	21	20	24	14	108	167	1154	27·0
7	14	17	11	8	12	19	50	220	1205	28·9
8	34	29	25	23	20	15	111	159	1173	28·0
9	28	32	21	22	11	12	103	167	1149	26·7
10	20	30	18	12	23	11	80	190	1173	29·0
Aver....	27	28	20	19	18	14	94	176	1177	28·2

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	13	18	21	16	18	17	68	202		
2	66	45	31	27	15	15	169	101		
3	55	47	28	30	12	18	160	110		
4	60	43	31	29	20	13	163	107		
5	27	22	27	23	16	17	99	171		
6	65	49	30	26	18	10	170	100	(As above.)	
7	57	45	27	21	14	19	150	120		
8	58	50	35	24	19	14	167	103		
9	67	48	36	28	17	21	179	91		
10	33	18	21	22	12	13	93	177		
Aver...	50	38	29	25	16	16	142	128		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside. 30in.	Velocity.	Recoil.
1	113	62	24	15	14	9	214	56		
2	100	51	22	20	17	13	193	77		
3	105	60	24	19	10	11	208	62		
4	103	48	33	24	18	9	208	62		
5	99	70	28	22	13	14	219	51		
6	120	52	21	18	15	10	211	59	(As above.)	
7	57	45	29	29	26	22	160	110		
8	101	65	20	18	14	12	204	66		
9	110	49	25	24	16	7	208	62		
10	108	47	31	11	16	16	197	73		
Aver...	101	55	26	20	16	11	202	68		

LEFT BARREL, 33grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·13 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	31	34	19	25	14	23	109	161		
2	27	10	16	18	11	11	71	199		
3	24	18	14	24	15	20	80	190		
4	21	20	20	14	16	14	75	195		
5	35	29	25	22	19	13	111	159		
6	18	34	20	20	16	23	92	178	(As above.)	
7	30	22	18	24	17	16	94	176		
8	31	35	27	21	15	13	114	156		
9	29	27	26	19	20	15	101	169		
10	26	34	22	23	18	20	105	165		
Aver....	27	26	21	21	16	17	95	175		

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	70	41	34	28	15	15	173	97		
2	65	50	28	22	16	13	165	105		
3	61	37	33	26	18	10	157	113		
4	60	43	30	23	20	14	156	114		
5	58	55	25	22	21	16	160	110		
6	69	47	24	27	19	11	167	103		(As before.)
7	51	41	34	20	17	17	146	124		
8	70	39	36	25	20	13	170	100		
9	63	43	27	26	28	16	159	111		
10	19	17	10	21	13	16	76	194		
Aver.	59	41	29	24	19	14	153	117		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	113	59	30	18	16	11	220	50		
2	121	61	29	17	9	5	223	43		
3	105	43	39	24	13	8	210	60		
4	114	58	36	20	14	10	223	43		
5	55	43	37	25	18	16	159	111		
6	109	53	40	23	15	11	224	46		(As above.)
7	118	56	30	20	6	9	224	46		
8	116	54	35	11	11	3	216	54		
9	120	60	33	13	8	5	226	44		
10	101	55	38	25	11	7	219	51		
Aver.	107	54	35	19	12	8	215	55		

20-BORE, No. 1043; weight, 5lb. 10oz.; barrels, 27in.

[With Smaller Charge of Shot.]

RIGHT BARREL, 31grs. powder; ¾oz. of shot (283 pellets); gas pressure, 2·20 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	46	28	24	29	9	14	127	109	1195	22·6
2	35	37	29	24	17	13	125	111	1220	23·0
3	19	11	17	11	8	14	58	178	1172	21·2
4	43	23	28	25	12	11	124	112	1167	21·0
5	38	35	25	23	19	13	121	115	1195	22·0
6	27	31	28	19	11	13	105	131	1154	20·0
7	41	25	23	21	15	12	110	126	1168	21·8
8	13	11	25	13	16	11	62	174	1190	22·3
9	48	28	26	27	18	10	129	107	1168	21·5
10	37	33	23	17	15	22	110	126	1181	23·0
Aver.	35	26	25	21	14	14	107	129	1180	21·7

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	62	52	20	20	23	19	154	82		
2	70	40	35	22	18	9	167	69		
3	75	44	27	19	13	10	165	71		
4	27	16	26	17	14	27	86	150		
5	66	43	34	20	20	16	163	73		
6	68	50	29	21	17	13	168	68		(As above.)
7	74	46	33	23	10	11	176	60		
8	63	49	31	25	26	15	168	68		
9	69	53	23	13	9	21	157	79		
10	71	41	26	27	27	19	165	71		
Aver.	65	43	28	21	18	16	157	79		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil
1	76	63	45	24	15	11	207	29		
2	99	53	33	17	8	3	202	34		
3	118	55	22	14	5	4	209	27		
4	123	46	20	15	10	6	204	32		
5	114	63	18	12	6	1	207	29		
6	117	63	31	5	9	5	216	20		(As above.)
7	120	50	18	13	7	4	201	35		
8	104	62	20	16	12	10	202	34		
9	95	58	27	18	11	7	198	38		
10	122	49	25	12	6	6	201	35		
Aver.	109	55	28	15	9	6	205	31		

LEFT BARREL, 31grs. powder; ¾oz. of shot (236 pellets); gas pressure 2·20 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	43	33	32	20	21	16	128	108		
2	51	30	27	27	16	15	135	101		
3	36	27	26	23	15	14	112	124		
4	48	35	30	20	18	10	133	103		
5	40	27	24	21	12	16	112	124		
6	45	28	27	23	20	11	123	113		(As before.)
7	26	30	28	17	19	12	101	135		
8	50	33	17	16	14	10	116	120		
9	39	31	25	25	17	9	120	116		
10	20	18	21	19	18	16	78	158		
Aver.	40	29	26	21	17	13	116	120		

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	76	45	24	21	19	15	166	70		
2	62	42	38	29	15	11	171	65		
3	84	47	21	22	18	12	174	62		
4	65	35	33	26	21	10	159	77		
5	72	47	26	28	17	13	173	63		
6	64	47	25	23	13	15	159	77		(As above.)
7	70	50	31	20	18	14	171	65		
8	83	45	29	28	11	10	184	52		
9	65	46	36	23	11	9	170	66		
10	63	34	28	24	20	13	149	87		
Aver.	70	44	29	24	16	12	167	69		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	118	41	24	13	8	9	196	40		
2	120	46	21	16	9	7	203	33		
3	124	40	20	17	2	2	201	35		
4	108	51	32	15	11	4	206	30		
5	130	43	18	8	5	6	199	37		
6	121	42	22	11	11	8	196	40		(As above.)
7	98	55	32	20	12	11	205	31		
8	117	47	28	19	10	5	211	25		
9	115	53	19	16	5	3	203	33		
10	128	45	23	12	7	2	207	29		
Aver.	118	46	24	15	8	6	203	33		

20-BORE, No. 1012; weight, 5lb. 13½oz.; barrels, 29in.

Barometer, 29·80; Thermometer, Dry 55°, Wet 51°.

RIGHT BARREL, 32grs. powder; 1oz. of shot (270 pellets); gas pressure. 3·06 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	38	30	21	17	14	16	106	164	1167	25·7
2	22	19	19	9	12	10	63	208	1220	27·3
3	45	36	23	18	9	19	122	148	1220	27·4
4	40	32	28	20	15	12	118	152	1167	26·2
5	50	30	20	16	13	10	116	154	1158	25·8
6	29	29	27	17	16	15	102	168	1176	26·7
7	43	23	25	15	12	11	106	164	1163	26·0
8	31	26	21	18	18	17	96	174	1200	27·1
9	52	27	23	19	13	15	114	156	1141	25·5
10	25	26	13	19	20	13	88	187	1167	26·0
Aver.	37	27	22	16	14	14	102	168	1178	26·4

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	65	54	38	25	15	16	182	88		
2	60	43	34	27	23	14	164	106		
3	58	45	39	26	19	19	168	102		
4	70	44	36	20	21	10	170	100		
5	84	59	33	26	13	9	207	63		
6	66	40	33	21	18	13	160	110		(As above.)
7	33	34	41	24	22	15	132	138		
8	71	42	31	28	17	11	172	98		
9	58	48	33	21	14	13	165	105		
10	64	41	33	27	22	18	164	106		
Aver.	63	45	36	24	18	14	168	102		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	112	65	27	29	13	4	233	37		
2	142	47	30	22	12	6	241	29		
3	162	50	23	8	4	2	243	27		
4	137	66	20	15	10	3	288	32		
5	153	54	25	11	6	4	243	27		
6	118	60	26	25	11	7	229	41	(As before.)	
7	59	55	37	35	23	19	186	84		
8	160	48	25	17	9	5	250	20		
9	153	55	23	12	3	3	243	27		
10	109	63	28	12	11	8	212	58		
Aver.	131	56	26	19	10	6	232	38		

LEFT BARREL, 32grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·06 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	40	32	27	27	25	9	126	144		
2	42	36	34	29	14	16	141	129		
3	51	42	35	21	17	11	149	121		
4	66	47	24	19	21	15	156	114		
5	45	39	33	23	19	17	140	130		
6	40	43	39	18	12	15	140	130	(As above.)	
7	55	35	31	26	20	13	147	123		
8	27	23	19	18	16	20	87	183		
9	48	39	28	22	18	14	137	133		
10	33	29	26	27	14	12	114	156		
Aver.	45	36	30	23	18	14	134	136		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	64	50	36	14	16	13	164	106		
2	84	54	24	16	13	9	178	92		
3	77	48	40	22	18	11	187	83		
4	71	43	31	19	15	14	164	106		
5	79	47	33	20	16	12	179	91		
6	62	55	38	23	20	16	178	92	(As above.)	
7	80	48	26	18	12	10	172	98		
8	53	45	50	31	19	12	179	91		
9	86	52	35	20	17	15	193	77		
10	75	54	37	21	14	13	187	83		
Aver.	73	50	35	20	16	13	178	92		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	190	46	12	2	5	1	250	20		
2	153	65	28	10	3	2	251	19		
3	181	51	18	5	0	1	255	15		
4	151	58	22	11	8	5	242	28		
5	175	53	23	7	2	1	258	12		
6	180	63	11	3	1	0	253	10	(As above.)	
7	196	40	18	4	2	6	248	22		
8	172	55	21	6	4	1	254	16		
9	150	68	18	9	2	4	245	25		
10	115	50	30	11	10	8	206	64		
Aver.	165	55	20	7	4	3	247	23		

20-BORE, No. 1012; weight, 5lb. 13½oz.; barrels, 29in.

[With Smaller Charge of Shot.]

RIGHT BARREL, 30grs. powder; ⅞oz. of shot (236 pellets); gas pressure, 2·14 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft.lb.
1	51	37	26	21	15	12	135	101	1215	22·8
2	40	33	19	18	19	11	110	126	1149	19·5
3	41	35	32	14	16	20	122	114	1200	22·7
4	45	31	24	21	20	17	121	115	1154	20·5
5	40	32	22	24	12	12	118	118	1195	21·7
6	56	30	22	20	16	14	123	108	1176	21·2
7	45	40	33	23	18	11	139	97	1186	21·8
8	42	28	33	23	22	20	126	110	1154	19·7
9	48	44	30	23	17	13	145	91	1181	22·0
10	38	31	25	20	17	13	114	122	1158	20·8
Aver.	45	34	26	21	17	14	126	110	1177	21·2

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	58	51	32	13	15	9	154	82		
2	74	43	34	31	18	19	182	54		
3	85	34	27	27	25	20	173	63		
4	50	52	26	16	20	17	144	92		
5	62	43	31	21	16	2	157	79		
6	20	26	23	22	23	24	91	145	(As before.)	
7	71	45	36	28	17	15	180	56		
8	87	33	21	22	20	12	163	73		
9	80	41	28	25	19	18	174	62		
10	78	52	32	19	11	16	181	55		
Aver.	67	42	29	22	18	16	160	76		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	120	57	30	8	7	7	215	21		
2	112	66	20	12	8	2	210	26		
3	134	50	15	15	3	5	214	22		
4	126	62	21	9	5	3	218	18		
5	112	59	23	17	4	6	211	25		
6	131	43	28	16	7	5	218	18	(As above.)	
7	108	68	22	11	6	2	209	27		
8	122	55	35	8	5	3	220	16		
9	134	48	17	7	2	6	206	30		
10	117	53	22	13	8	4	205	31		
Aver.	122	56	23	12	5	4	215	23		

LEFT BARREL, 30grs. powder; ⅞oz. of shot (236 pellets); gas pressure, 2·14 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil
1	55	29	31	22	18	22	137	99		
2	62	41	27	20	17	12	150	86		
3	61	33	34	18	14	10	146	90		
4	53	26	26	22	12	20	127	109		
5	58	30	22	20	16	13	130	106		
6	51	38	30	23	22	15	142	94	(As above.)	
7	60	66	29	18	11	8	173	63		
8	51	43	25	21	18	14	140	96		
9	67	49	33	19	15	11	168	68		
10	55	37	31	21	19	10	144	92		
Aver.	57	39	29	21	16	13	146	90		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	111	45	30	11	8	15	197	39		
2	117	61	27	19	5	2	224	12		
3	88	59	33	25	13	5	205	31		
4	121	63	21	13	7	2	218	18		
5	91	66	30	18	10	6	205	31		
6	86	52	32	17	14	10	187	49	(As above.)	
7	120	45	23	14	5	3	203	34		
8	97	58	35	20	11	5	210	26		
9	123	60	29	12	5	3	224	12		
10	109	63	19	12	6	7	209	34		
Aver.	106	57	28	16	8	6	207	29		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	123	34	22	10	1	2	189	47		
2	172	31	13	7	4	0	223	13		
3	160	29	15	3	2	2	207	29		
4	159	34	19	7	6	3	219	17		
5	176	26	11	1	1	0	214	22		
6	168	28	15	4	2	2	215	21	(As above.)	
7	147	37	18	6	3	1	208	28		
8	159	33	20	12	5	2	223	13		
9	164	39	11	5	0	1	219	17		
10	186	20	11	5	0	0	222	14		
Aver.	161	31	16	6	2	1	214	22		

("*Field*," *April* 25, 1896; *Vol.* 87, *p.* 617.)

IN THESE REPORTS we have now added records of temperature and barometrical pressure, as we thought they might possibly prove useful in making comparisons between different experiments. For instance, it will have been observed that, although we have loaded the cartridges with the number of grains of powder found requisite to impart a mean velocity of 1160 ft.sec. in 10 yards range, yet some of the guns do not come quite up to this average, while others considerably exceed it. It must not be imagined, however, that these variations above and below indicate any superiority or inferiority in the guns. They are rather to be taken as representing a change in the state of the atmosphere. Of course, when ten successive rounds are fired from the same gun, under exactly the same conditions, it may be assumed that variations in strength of the ten caps may probably account for some of the cartridges giving higher velocity and more recoil than others do. We find, however, that when a batch of cartridges has been specially loaded to produce a given result, that result is often more or less varied by changes in the weather which have occurred since the cartridges were loaded—a dull, heavy state of the atmosphere lowering the velocity, while warmth and brightness have the opposite effect. On some days the alternations are so sudden that the same gun may show variations of performance at different parts of its trial; but it is practically impossible to identify every vagary of the atmosphere with a special portion of the gun's record, so we have adopted the course of giving the average effects by taking notes of the height of the barometer and thermometer from time to time, and, when there are variations, giving the average readings of the whole. In the early portion of the experiments, about six weeks ago, there was comparatively little variation; but with the rise in the temperature the facts were forced upon our attention by guns requiring a grain or two less powder to produce the same velocity. Thus it will be seen that 12-bore No. 7255, tried a few days ago, gave just about the same velocity as No. 1072, which had been previously tried, although there was a difference of two grains in the charge of powder and the barrels were of equal length.

12-BORE, No. 7255; weight, 5lb. 3oz.; barrels, 26in.

Barometer, 29·65; Thermometer—Dry 53°, Wet 50°.

RIGHT BARREL, 37grs. powder; 1oz. of shot (270 pellets); gas pressure, 1·67 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	60	51	35	21	14	11	167	103	1158	27·8
2	52	45	37	19	16	14	153	117	1167	28·4
3	55	47	33	20	13	12	155	115	1163	28·7
4	45	39	27	25	22	16	136	134	1216	32·0
5	51	48	30	24	18	14	153	117	1172	30·1
6	49	45	28	23	24	15	145	125	1145	27·3
7	58	52	33	27	15	12	170	100	1163	28·0
8	37	30	29	20	23	12	116	154	1186	30·5
9	40	33	30	20	15	15	123	147	1149	27·4
10	57	44	38	16	14	15	155	115	1172	30·0
Aver...	50	43	32	22	17	14	147	123	1168	29·0

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	50	40	24	16	14	174	96		
2	91	70	27	21	13	9	217	53		
3	71	62	40	17	22	10	190	80		
4	83	68	29	25	17	12	205	65		
5	76	52	38	23	20	15	188	82		
6	88	71	36	18	11	9	208	62	(As above.)	
7	71	54	33	26	15	13	183	87		
8	68	48	37	20	12	8	173	97		
9	60	45	39	23	14	11	167	103		
10	75	56	35	26	18	14	193	78		
Aver...	74	58	35	22	16	11	189	81		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	139	49	14	6	4	6	208	62		
2	122	51	28	11	8	3	212	58		
3	140	48	10	2	3	4	200	70		
4	123	46	21	18	11	9	208	62		
5	153	39	13	7	5	2	211	59		
6	131	41	16	10	6	5	198	72	(As before.)	
7	118	52	23	9	4	2	201	69		
8	141	42	18	5	3	1	206	64		
9	102	50	37	23	14	14	211	59		
10	126	49	27	14	10	8	216	54		
Aver...	129	47	21	10	7	5	207	63		

LEFT BARREL, 37grs. powder; 1oz. of shot (270 pellets); gas pressure, 1·67 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	67	42	27	22	20	15	158	112		
2	70	46	27	28	17	10	171	99		
3	34	30	23	26	25	22	113	157		
4	58	45	36	24	19	19	163	107		
5	40	22	28	23	23	17	113	157		
6	65	44	28	28	23	16	165	105	(As above.)	
7	59	40	37	27	24	20	163	107		
8	69	46	23	20	18	14	158	112		
9	59	34	33	24	16	18	129	141		
10	53	36	39	26	20	21	154	116		
Aver...	57	38	30	25	20	17	150	120		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	73	44	42	39	16	13	198	72		
2	86	52	32	30	15	16	200	70		
3	38	23	26	23	15	21	110	160		
4	87	48	34	30	18	10	199	71		
5	74	53	46	29	13	7	202	68		
6	91	42	35	23	11	9	191	79	(As above.)	
7	77	50	42	26	19	11	195	75		
8	80	58	33	21	17	9	192	78		
9	82	49	38	32	15	14	201	69		
10	76	46	34	36	18	12	192	78		
Aver...	76	47	36	29	16	12	198	82		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	160	28	13	8	4	1	298	42		
2	171	36	21	11	7	4	239	31		
3	149	49	18	7	10	2	213	57		
4	162	43	15	9	2	2	229	41		
5	165	34	20	12	9	4	231	39		
6	151	42	11	6	3	0	210	60	(As above.)	
7	160	37	23	8	6	3	228	42		
8	144	40	19	14	8	5	217	53		
9	156	48	16	10	4	2	230	40		
10	173	35	20	9	5	0	237	33		
Aver...	161	39	17	9	6	2	226	44		

12-BORE, No. 7255; weight, 5lb. 3oz.; barrels, 26in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, 36grs. powder; ⅞oz. of shot (236 pellets); gas pressure, 1·48 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	32	48	37	27	21	11	144	92	1141	23·2
2	26	10	20	8	12	10	64	172	1181	26·5
3	48	34	29	24	17	13	135	101	1145	23·5
4	50	39	30	27	13	9	146	90	1145	23·0
5	47	35	22	17	15	11	121	115	1176	24·0
6	54	32	20	25	11	14	131	105	1163	23·7
7	41	31	24	20	18	17	110	120	1136	22·8
8	50	37	26	19	17	18	133	104	1210	27·5
9	53	31	30	14	15	15	128	108	1186	26·0
10	45	38	33	16	16	11	132	104	1172	24·6
Aver...	45	33	27	20	15	13	125	111	1165	24·5

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	72	60	28	19	16	14	179	57		
2	80	56	23	22	10	9	181	55		
3	120	38	23	19	4	4	200	36		
4	71	58	35	14	13	11	178	58		
5	30	17	19	16	18	16	82	154		
6	92	45	22	20	10	9	179	57	(As before.)	
7	88	51	26	21	13	10	196	50		
8	85	54	20	18	15	12	177	59		
9	63	63	33	12	11	15	171	65		
10	96	57	31	21	14	2	205	31		
Aver...	80	50	26	18	12	10	174	62		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	156	43	14	5	2	0	218	18		
2	142	50	17	7	4	5	216	20		
3	133	44	15	4	2	3	196	40		
4	124	46	16	8	7	4	194	38		
5	114	59	22	6	5	2	201	35		
6	158	36	13	5	3	1	212	24	(As above.)	
7	160	27	11	3	2	2	201	35		
8	121	55	20	11	6	4	207	29		
9	146	48	12	7	1	0	213	23		
10	140	36	14	2	2	3	192	44		
Aver...	139	44	15	6	4	2	204	32		

LEFT BARREL, 38grs. powder; 1oz. of shot (236 pellets); gas pressure, 1·48 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	46	37	23	20	13	16	126	110		
2	71	31	30	20	12	16	152	84		
3	26	15	23	14	15	16	78	158		
4	55	32	27	10	8	12	124	112		
5	66	48	24	16	15	13	154	82	(As above.)	
6	61	51	26	7	10	11	145	91		
7	52	39	31	18	16	15	140	96		
8	70	33	29	22	18	10	154	82		
9	60	35	28	16	11	14	139	97		
10	58	40	30	19	13	9	147	89		
Aver...	57	36	27	16	13	13	136	100		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	66	51	30	30	12	10	177	59		
2	110	42	23	16	14	8	191	45		
3	90	39	25	13	11	9	167	69		
4	109	52	24	15	9	5	200	36		
5	82	51	20	20	6	6	179	63		
6	101	48	21	17	12	9	187	49	(As above.)	
7	105	55	24	13	7	7	197	39		
8	97	50	27	20	10	4	194	42		
9	104	45	22	18	7	5	189	47		
10	90	53	32	18	11	7	193	43		
Aver...	95	49	25	18	10	7	187	49		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	170	33	14	7	5	2	224	12		
2	152	45	10	8	6	2	215	21		
3	161	36	5	4	5	3	206	30		
4	153	58	13	6	2	0	230	6		
5	175	24	11	7	3	4	217	19		
6	149	47	12	5	4	1	213	23	(As above.)	
7	161	40	10	6	2	4	217	19		
8	152	50	9	8	4	0	219	17		
9	136	54	12	7	6	2	209	27		
10	164	37	13	6	2	3	220	16		
Aver...	157	42	11	6	4	2	216	20		

20-BORE, No. 2365; weight, 5lb. 15½oz.; barrels, 30in.
Barometer, 29·50; Thermometer—Dry 58°, Wet 53°.

RIGHT BARREL, 32grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·06 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circ'e.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	55	42	32	23	31	25	151	119	1167	23·5
2	30	44	23	25	20	20	125	145	1205	24·8
3	43	35	30	27	19	16	140	130	1176	24·3
4	35	28	27	30	21	22	120	150	1176	24·8
5	50	48	30	27	19	17	155	115	1172	23·5
6	52	33	31	21	25	23	137	133	1154	24·6
7	33	36	36	29	24	18	139	131	1163	23·8
8	41	39	41	31	18	18	152	118	1181	24·7
9	45	43	25	23	20	15	136	134	1141	23·5
10	57	41	23	22	17	19	148	122	1172	24·0
Aver...	45	39	31	26	20	19	141	129	1170	24·1

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	63	48	36	31	18	13	178	92		
2	77	50	34	20	24	17	181	89		
3	109	61	34	19	7	7	223	47		
4	56	34	28	28	17	17	146	124		
5	95	57	30	26	16	15	208	62		
6	83	56	27	23	14	11	189	81	(As above.)	
7	78	48	35	30	18	10	191	79		
8	97	54	33	25	16	8	209	61		
9	86	59	31	22	20	18	198	72		
10	78	61	36	35	15	16	210	60		
Aver...	82	53	32	26	16	13	193	77		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	146	62	30	11	2	1	249	21		
2	170	58	19	6	3	2	258	17		
3	151	55	21	10	2	2	237	39		
4	156	57	22	13	2	3	248	22		
5	165	51	20	9	4	1	245	25	(As above.)	
6	187	43	12	2	1	0	244	26		
7	155	65	23	11	6	3	254	16		
8	168	52	15	7	3	2	249	23		
9	181	48	18	5	1	0	251	19		
10	153	60	21	6	4	4	240	30		
Aver...	163	55	20	8	3	2	246	24		

LEFT BARREL, 32grs. powder; 1oz. of shot (270 pellets); gas pressure, 3·36 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	43	38	21	25	22	12	127	143		
2	55	48	29	22	20	16	154	116		
3	53	43	30	26	19	13	151	119		
4	45	50	32	21	12	16	148	122		
5	69	26	25	17	30	17	137	133		
6	40	36	31	26	17	15	133	137	(As above.)	
7	61	37	27	20	20	18	145	125		
8	53	31	23	30	22	16	137	133		
9	58	43	30	24	19	11	155	115		
10	46	39	28	23	21	17	136	134		
Aver...	52	39	28	23	20	15	142	128		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	71	60	30	26	20	17	187	83		
2	94	68	22	19	17	11	203	67		
3	110	75	24	15	13	9	224	46		
4	74	45	38	35	14	12	192	78		
5	82	62	29	25	16	13	198	72		
6	97	70	23	18	12	10	208	62	(As above.)	
7	88	62	31	23	18	14	204	66		
8	66	57	36	26	25	20	185	85		
9	112	72	25	17	11	8	225	45		
10	95	59	42	24	22	12	220	50		
Aver...	89	63	30	23	17	13	205	65		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	198	41	18	1	0	0	258	12		
2	166	53	21	10	3	1	250	20		
3	180	56	16	5	4	2	257	13		
4	188	48	19	7	3	1	272	8		
5	143	58	31	11	13	7	242	23		
6	198	46	12	4	1	1	280	10		(As before.)
7	175	52	20	8	5	1	255	15		
8	165	60	17	6	4	3	248	19		
9	193	45	15	3	2	0	256	14		
10	177	61	18	5	3	2	261	9		
Aver...	178	53	19	6	4	2	255	15		

20-BORE, No. 2365; weight, 5lb. 15½oz.; barrels, 30in.

[With Smaller Charge of Shot.]

RIGHT BARREL, 30grs. powder; ¾oz. of shot (236 pellets); gas pressure, 2·14 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards.) Ft.sec.	Recoil Ft.lb.
1	37	30	18	24	14	10	109	127	1163	19·5
2	58	43	27	12	18	15	140	96	1149	18·8
3	35	48	33	29	17	14	145	91	1172	19·7
4	40	35	30	21	17	13	126	110	1181	20·2
5	43	40	35	23	18	10	140	96	1158	19·0
6	33	37	20	27	25	15	117	119	1215	21·1
7	48	34	29	24	19	13	135	101	1190	20·0
8	56	41	26	25	12	15	148	88	1141	18·9
9	48	39	31	22	20	17	140	96	1158	19·3
10	55	43	26	20	16	11	144	92	1167	19·5
Aver...	45	39	27	23	18	13	134	102	1169	19·6

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	44	52	30	17	13	12	143	93		
2	86	49	35	15	11	8	185	51		
3	75	50	32	21	20	12	178	58		
4	78	61	29	16	13	11	184	52		
5	66	64	31	19	12	9	180	56		
6	81	45	35	14	9	11	175	61		(As above.)
7	85	50	33	18	11	9	186	50		
8	68	58	34	20	17	10	180	56		
9	42	24	26	13	10	15	105	131		
10	72	41	36	19	13	13	168	68		
Aver...	70	49	32	17	13	11	168	68		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	159	42	8	2	1	2	211	25		
2	134	46	15	12	8	5	207	29		
3	145	40	10	8	4	3	208	33		
4	148	45	17	6	0	2	216	20		
5	150	38	13	9	6	4	210	26		
6	171	29	7	2	1	1	209	27		(As above.)
7	130	43	23	7	5	3	203	33		
8	144	41	12	10	7	4	207	29		
9	112	44	26	14	9	5	196	40		
10	165	32	11	5	3	1	213	23		
Aver...	146	40	14	7	4	3	207	28		

LEFT BARREL, 30grs. powder; ¾oz. of shot (236 pellets); gas pressure, 2·14 tons per square inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	36	21	18	21	17	19	96	140		
2	33	21	24	23	22	19	101	135		
3	67	42	20	28	12	12	157	79		
4	54	38	23	20	14	10	135	101		
5	60	41	26	24	17	13	151	85		
6	50	32	28	20	23	11	130	106		(As above.)
7	68	46	25	21	15	9	160	76		
8	30	25	18	15	8	12	88	148		
9	43	35	20	27	11	20	135	111		
10	65	39	28	26	16	10	158	78		
Aver...	51	34	23	22	15	13	130	106		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	81	45	40	18	13	11	184	52		
2	96	47	31	22	15	10	196	40		
3	91	51	27	20	13	8	189	47		
4	87	46	36	16	11	7	185	51		
5	73	50	31	30	15	4	184	52		
6	88	55	28	19	12	10	190	46		(As before.)
7	87	47	38	21	9	9	193	43		
8	92	52	30	13	11	5	187	49		
9	95	49	26	15	6	14	185	51		
10	84	42	27	23	20	10	176	60		
Aver...	87	48	31	20	12	9	186	50		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	162	32	18	6	2	2	218	18		
2	153	37	23	3	6	3	216	20		
3	138	55	19	8	8	2	220	16		
4	153	48	15	10	4	1	226	10		
5	174	39	9	2	2	2	224	12		
6	148	55	17	7	1	3	227	9		(As above.)
7	119	46	28	12	8	6	205	31		
8	136	56	20	5	3	3	217	19		
9	121	45	23	24	11	8	212	24		
10	169	30	17	9	2	0	225	11		
Aver...	147	44	19	9	5	3	219	17		

("*Field*," *May* 2, 1896; *Vol.* 67, *p.* 657.)

TWO MORE 16-BORES have been tried in the present week. One (No. 2861) reaches the full limit in weight, viz., 6lb., and is the longest of the guns of that gauge yet tested; the other is No. 7380, which is the shortest of the 16-bores tried. Both gave very good results. Owing, probably, to the warmer weather, the short gun did not require quite so much powder as some of those which had been tried on cooler days, although ordinarily the short barrel requires more powder and also gives more recoil.

16-BORE GUN, No. 2861; weight, 6lb.; barrels, 29in.

Barometer, 29·95; Thermometer—Dry 63°, Wet 57°.

RIGHT BARREL, powder, 36grs.; shot, 1oz. (270 pellets); gas pressure, 2·66 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	57	29	25	20	15	13	131	139	1149	25·0
2	45	36	24	22	19	15	127	143	1205	26·9
3	47	27	25	22	19	11	121	149	1141	26·5
4	50	31	26	24	17	14	131	139	1195	26·9
5	43	32	28	21	18	17	124	146	1167	25·9
6	23	19	23	20	14	15	84	186	1154	25·5
7	54	26	27	19	19	13	126	144	1181	26·3
8	43	36	26	28	20	18	133	137	1163	26·0
9	51	29	24	23	16	11	127	143	1154	25·7
10	41	35	20	18	11	17	114	156	1186	26·8
Aver...	45	30	25	22	17	14	122	148	1169	25·1

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	72	45	36	26	16	10	179	91		
2	26	32	28	21	14	15	107	163		
3	64	56	34	20	12	16	184	86		
4	52	55	45	27	25	18	179	91		
5	70	48	31	35	18	13	184	86		
6	63	52	38	29	20	17	182	83		(As above.)
7	58	54	41	33	17	15	186	84		
8	67	38	34	20	19	19	159	111		
9	66	58	33	24	22	11	181	89		
10	54	47	41	32	18	14	174	96		
Aver...	59	48	36	28	18	15	171	99		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	138	60	31	18	8	4	247	23	
2	133	52	40	19	4	6	214	26	
3	130	65	31	14	8	3	240	30	
4	122	73	35	12	7	5	242	28	
5	101	59	42	31	19	11	232	38	
6	127	68	29	16	6	2	240	30	(As before.)
7	131	74	34	14	3	3	253	17	
8	128	61	36	20	10	8	245	25	
9	119	63	33	23	15	9	238	32	
10	140	58	30	17	6	4	245	25	
Aver...	127	63	34	18	9	5	242	28	

LEFT BARREL, powder 36grs.; shot 1oz. (270 pellets); gas pressure, 2·66 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	40	40	31	26	21	25	137	133	
2	37	38	31	20	17	14	126	144	
3	30	35	22	17	14	15	104	166	
4	51	37	30	25	11	11	143	127	
5	38	33	29	27	16	15	127	143	
6	45	39	24	24	14	12	132	138	(As above.)
7	48	32	26	23	19	17	129	141	
8	43	41	33	25	15	13	142	128	
9	55	36	28	20	18	16	139	131	
10	33	38	21	29	16	21	121	149	
Aver...	42	37	27	24	16	16	130	140	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	76	54	37	24	16	11	191	79	
2	84	48	34	22	19	15	198	82	
3	80	57	38	20	14	10	195	75	
4	85	53	33	30	11	13	201	69	
5	56	43	44	19	22	18	161	109	
6	62	50	33	25	22	20	170	100	(As above.)
7	81	56	35	22	18	14	194	76	
8	58	55	38	20	25	19	171	99	
9	77	54	40	31	17	11	202	68	
10	72	52	35	25	15	12	184	86	
Aver...	73	52	37	24	18	14	186	84	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside. 30in.	Velocity. Recoil.
1	141	63	34	13	12	6	251	19	
2	138	59	31	18	10	8	246	24	
3	132	65	33	16	9	10	246	24	
4	140	68	29	13	7	5	250	20	
5	149	52	32	20	12	3	253	17	
6	150	50	35	12	5	1	247	23	(As above.)
7	127	49	36	26	12	12	238	32	
8	142	62	30	17	9	4	251	19	
9	147	54	34	14	8	6	249	21	
10	135	57	32	19	11	5	243	27	
Aver...	140	58	32	17	9	6	247	23	

16-BORE GUN, No. 2361; weight, 6lb.; barrels, 29in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, powder, 34grs.; shot, ⅞oz. (236 pellets); gas pressure, 1·25 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	41	30	22	16	15	14	109	127	1145	22·8
2	20	21	21	21	17	18	83	153	1141	22·4
3	43	28	18	18	20	14	107	129	1172	22·8
4	37	33	25	20	19	15	115	121	1220	23·0
5	21	19	18	11	21	20	69	167	1154	22·5
6	47	26	21	16	16	18	110	126	1172	22·7
7	35	23	24	22	20	17	104	132	1167	22 8
8	22	20	18	14	17	13	74	162	1145	22·1
9	45	25	22	19	20	14	111	125	1200	23·2
10	39	27	24	24	18	16	114	122	1167	22·6
Aver...	35	25	22	18	18	16	100	136	1169	22·7

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	60	44	30	21	15	10	155	81	
2	54	39	37	28	18	12	158	78	
3	23	25	28	26	16	17	102	134	
4	64	41	31	20	14	9	156	80	
5	57	33	22	26	21	16	138	98	
6	65	48	35	22	17	12	170	66	(As before.)
7	62	50	31	23	19	17	166	70	
8	58	37	31	33	13	14	159	77	
9	44	40	34	37	24	16	145	91	
10	62	48	39	19	12	5	163	68	
Aver...	55	41	32	24	17	13	152	84	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	106	50	34	18	8	11	208	28	
2	120	56	25	12	5	3	213	23	
3	103	63	27	14	9	6	207	29	
4	109	57	29	19	11	5	214	22	
5	81	52	39	17	19	9	189	47	
6	114	61	22	15	7	6	212	24	(As above.)
7	116	58	24	11	13	4	209	27	
8	103	52	31	18	10	8	204	32	
9	110	50	36	11	14	3	207	29	
10	104	58	33	16	9	6	211	25	
Aver...	106	56	30	15	10	6	207	29	

LEFT BARREL, powder, 34grs.; shot, ⅞oz. (236 pellets); gas pressure, 1·25 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	40	38	29	23	19	10	130	106	
2	27	24	22	29	16	17	102	134	
3	50	33	25	20	17	21	128	108	
4	13	21	16	20	13	13	70	166	
5	41	35	30	26	13	10	132	104	
6	47	29	15	25	11	18	116	120	(As above.)
7	42	37	24	21	16	14	124	112	
8	29	25	22	24	20	20	100	136	
9	51	32	27	22	14	11	132	104	
10	45	36	23	20	11	15	124	112	
Aver...	39	31	23	23	15	15	116	120	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	69	47	32	19	12	11	167	69	
2	45	37	29	31	20	13	142	94	
3	62	22	36	29	18	23	149	87	
4	68	44	27	23	13	9	162	74	
5	43	30	31	26	16	16	130	106	
6	72	40	29	25	16	17	166	70	(As above.)
7	61	45	33	22	15	10	163	73	
8	74	43	34	24	17	14	175	61	
9	70	43	35	29	14	12	171	65	
10	66	48	28	23	19	11	165	71	
Aver...	63	40	31	24	16	14	158	78	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	126	59	21	18	2	2	294	12	
2	130	63	17	10	4	5	220	16	
3	130	56	16	13	8	1	215	21	
4	103	52	40	18	3	5	218	18	
5	121	63	17	15	6	4	216	20	
6	119	65	22	12	10	5	218	18	(As above.)
7	133	58	19	11	5	2	221	15	
8	115	54	34	20	3	3	223	13	
9	124	61	20	12	7	6	217	19	
10	135	62	11	9	3	1	217	19	
Aver...	124	59	22	14	3	3	219	17	

16-BORE GUN, No. 7330; weight, 5lb. 12oz.; barrels, 26in.

Barometer, 29·80; Thermometer—Dry 61°; Wet 56°.

RIGHT BARREL, powder, 35grs.; shot, 1oz. (270 pellets); gas pressure, 2·61 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	25	30	30	18	16	20	108	167	1181	29·0
2	40	31	27	24	18	13	123	148	1163	27·1
3	44	27	26	28	17	15	120	150	1154	26·9
4	35	33	25	25	15	10	118	152	1172	28·7
5	26	26	33	27	15	14	112	158	1205	29·6
6	42	25	29	16	16	18	112	158	1141	26·1
7	39	34	30	21	18	16	124	146	1172	27·7
8	38	25	18	25	16	19	106	164	1172	29·0
9	41	30	25	20	19	10	116	154	1145	26·5
10	28	27	20	22	13	24	97	173	1167	28·3
Aver...	36	29	26	22	16	16	113	157	1167	27·9

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	62	29	28	28	15	16	145	125		
2	45	39	28	23	24	16	135	135		
3	68	38	27	23	19	13	156	114		
4	56	42	40	21	16	15	159	111		
5	62	34	32	20	23	21	148	122		
6	65	39	26	22	20	14	152	118		(As above.)
7	51	48	35	27	18	11	161	109		
8	54	46	24	24	21	18	148	122		
9	60	37	33	21	17	12	151	119		
10	58	41	30	25	20	15	154	116		
Aver...	58	39	30	26	20	15	150	120		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	133	53	35	16	11	9	237	33		
2	131	59	26	14	6	5	223	47		
3	99	68	41	18	10	8	226	44		
4	136	63	24	17	9	6	240	30		
5	132	51	32	22	8	4	237	33		
6	125	65	30	16	7	5	236	34		(As above.)
7	135	62	25	15	8	9	237	33		
8	138	55	23	13	11	3	223	42		
9	97	53	34	26	15	10	210	60		
10	131	53	29	17	10	7	235	35		
Aver...	126	58	30	17	9	7	231	39		

LEFT BARREL, powder, 35grs.; shot, 1oz. (270 pellets); gas pressure, 2·61 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	49	41	27	20	15	12	137	133		
2	59	32	29	19	18	21	130	131		
3	20	26	24	21	16	17	91	179		
4	43	46	34	16	14	17	130	131		
5	33	21	25	14	13	13	99	177		(As above.)
6	47	45	33	18	11	10	143	127		
7	50	35	32	20	15	18	137	133		
8	54	33	28	19	17	11	139	131		
9	27	24	19	25	13	15	95	175		
10	56	33	30	21	16	14	140	130		
Aver...	44	34	28	19	15	15	135	145		

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	80	61	34	17	16	16	192	78		
2	68	50	32	20	15	12	179	100		
3	76	45	28	23	21	11	182	88		
4	71	62	35	19	17	20	187	83		
	79	56	33	21	13	10	189	81		
	64	48	40	29	18	12	181	89		(As above.
7	82	56	32	19	13	9	191	79		
8	72	55	36	25	19	12	188	82		
9	76	34	35	20	14	13	167	108		
10	66	51	37	22	16	11	176	94		
Aver...	74	52	35	21	16	13	182	93		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	160	55	21	8	2	3	244	26		
2	147	61	19	10	6	4	237	33		
3	143	54	22	3	7	2	227	43		
4	162	57	16	6	3	0	241	29		
5	151	59	18	8	4	2	236	34		
6	143	66	20	11	8	2	240	30		(As before.)
7	160	51	19	7	3	3	237	33		
8	141	63	20	9	5	1	236	34		
9	159	62	15	6	4	3	242	28		
10	152	43	28	12	7	4	235	35		
Aver...	152	57	20	8	5	2	237	32		

16-BORE GUN, No. 7330; weight, 5lb. 12oz.; barrels, 26in.

[With Smaller Charge of Shot.]

RIGHT BARREL, powder, 34grs.; shot, ¾oz. (236 pellets); gas pressure, 1·25 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	27	20	29	23	12	18	99	137	1161	24·4
2	42	25	25	21	21	18	113	123	1163	25·0
3	27	20	23	27	17	19	97	139	1158	23·0
4	45	30	26	21	20	15	122	114	1136	22·6
5	26	23	20	24	15	20	93	143	1215	25·1
6	38	24	29	12	10	16	103	133	1154	23·3
7	40	27	24	23	18	13	114	122	1176	24·1
8	42	30	23	26	17	15	126	110	1154	23·5
9	39	27	27	25	20	17	118	118	1167	23·4
10	47	28	25	20	16	14	120	116	1149	23·0
Aver...	37	25	26	22	17	16	110	125	1165	23·7

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	67	48	30	22	16	10	167	69		
2	53	50	28	26	15	11	157	79		
3	65	43	24	21	18	14	153	83		
4	56	52	29	25	13	11	162	74		
5	50	33	31	27	17	16	141	95		
6	58	47	33	23	16	13	161	75		(As above.)
7	64	45	28	21	14	15	158	78		
8	52	51	30	28	19	12	161	75		
9	55	36	26	26	15	19	143	93		
10	50	42	34	24	17	16	150	86		
Aver...	57	45	29	24	16	14	155	81		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	103	56	35	16	5	4	210	26		
2	101	62	38	12	10	6	213	23		
3	96	55	36	24	8	4	211	25		
4	114	52	35	9	7	2	210	26		
5	94	64	33	16	11	5	207	29		
6	93	65	32	14	18	4	204	32		(As above.)
7	110	58	31	7	6	3	206	30		
8	75	61	53	25	10	11	214	22		
9	97	58	37	17	9	7	204	32		
10	108	57	31	13	6	2	209	27		
Aver...	99	58	36	15	9	5	208	28		

LEFT BARREL, powder, 34grs.; shot, ¾oz. (236 pellets); gas pressure, 1·25 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	35	30	34	22	21	9	121	115		
2	26	36	27	23	14	12	112	124		
3	48	30	34	26	10	15	138	98		
4	38	26	24	26	11	12	114	122		
5	52	33	28	21	16	13	134	102		
6	45	39	31	25	14	11	140	96		(As above.)
7	55	35	25	18	12	16	133	103		
8	51	37	27	24	15	10	139	97		
9	43	31	26	28	13	12	133	103		
10	53	34	30	20	16	14	142	94		
Aver...	45	33	29	23	14	12	130	106		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	82	51	29	20	12	9	152	54		
2	59	45	27	22	21	15	153	83		
3	66	34	35	27	20	13	162	74		
4	75	48	31	25	12	8	179	57		
5	56	44	30	33	23	16	163	73		
6	69	49	39	21	15	11	178	58		(As before.)
7	80	51	31	17	11	7	179	57		
8	75	53	28	19	12	10	174	62		
9	63	42	42	23	14	11	169	67		
10	84	50	33	18	16	9	185	51		
Aver.	71	47	32	22	16	11	172	64		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	114	50	20	19	3	2	208	33		
2	133	60	15	12	4	1	220	16		
3	148	42	12	6	3	2	209	28		
4	145	45	17	8	6	3	215	21		
5	139	61	12	7	8	1	219	17		
6	150	56	15	4	2	0	225	11		(As above.)
7	112	63	30	9	5	3	214	22		
8	122	47	28	10	4	2	207	29		
9	141	50	13	8	7	1	212	24		
10	137	52	18	11	6	4	218	18		
Aver.	134	53	18	9	5	2	214	22		

("*Field*," *May* 9, 1896; *Vol.* 87, *p.* 698.)

THE TRIALS OF THE PRESENT WEEK commenced with a 20-bore gun (No. 9084) which presented a most remarkable series of close patterns. Both barrels are choked, and the left barrel a little more so than the right; but, as a rule, the first barrel with this gun gives closer patterns than the second barrel of its predecessors. The second gun tried this week was also a 20-bore (No. 2579), giving high patterns, though it was not so closely choked as its predecessor. It was two inches shorter in the barrels than No. 9084, but exactly the same weight; and, as usually is the case with shorter barrels, it gave rather higher recoil.

20-BORE, No. 9084; weight, 5lb. 7½oz.; barrels, 28in.

Barometer, 29·80; Thermometer—Wet, 55°; Dry, 55°.

RIGHT BARREL.—Powder, 32grs.; shot, 1oz. (270 pellets); gas pressure, 3·11 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	54	45	36	26	18	15	160	110	1136	24·7
2	65	41	35	23	15	13	164	106	1167	27·0
3	34	33	24	16	28	27	107	163	1154	25·8
4	68	44	33	22	20	14	167	103	1176	27·1
5	40	37	38	24	16	24	139	131	1172	26·7
6	26	29	26	29	14	12	110	160	1132	25·0
7	58	43	31	22	19	16	153	117	1181	27·3
8	55	46	36	21	17	14	158	112	1172	26·5
9	40	40	40	25	26	7	145	125	1167	26·6
10	61	48	37	23	15	11	169	101	1153	26·0
Aver.	50	41	33	23	19	15	147	123	1161	26·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	94	55	30	22	11	11	201	69		
2	100	71	31	24	6	6	226	44		
3	112	56	29	19	15	10	216	54		
4	109	63	33	15	14	8	220	50		
5	92	66	37	20	12	6	215	55		
6	112	58	23	18	16	8	211	59		(As above.)
7	107	65	30	21	10	9	223	47		
8	95	73	38	19	13	11	225	45		
9	103	49	41	24	14	6	217	53		
10	99	68	36	26	11	5	229	41		
Aver.	102	62	33	21	12	8	213	53		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	186	48	12	4	2	1	250	20		
2	181	60	10	5	4	2	256	14		
3	139	70	24	8	2	3	241	29		
4	174	64	13	6	4	0	257	13		
5	187	51	11	4	1	2	253	17		
6	175	62	12	7	2	3	256	14		(As before.)
7	151	67	24	4	7	2	246	24		
8	182	52	10	6	3	1	250	20		
9	211	33	2	3	2	0	254	16		
10	177	55	13	7	5	3	252	18		
Aver.	176	57	13	5	3	2	251	18		

LEFT BARREL.—Powder, 32grs.; shot, 1oz. (270 pellets); gas pressure, 3·11 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	64	54	33	28	15	14	179	91		
2	66	57	39	24	20	11	196	84		
3	42	48	40	22	18	16	152	118		
4	57	53	39	28	20	13	175	95		
5	29	28	35	13	18	17	105	165		
6	55	45	38	27	16	11	165	105		(As above.)
7	69	49	34	29	17	9	181	89		
8	61	60	36	23	15	10	180	90		
9	41	41	31	29	22	12	142	128		
10	70	55	34	25	16	10	184	86		
Aver.	55	49	36	25	18	12	165	105		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	118	65	37	20	11	5	240	30		
2	89	73	40	28	13	7	229	41		
3	97	68	38	30	13	10	233	37		
4	103	66	35	15	10	8	219	51		
5	120	64	34	17	12	5	235	35		
6	99	56	37	30	14	15	222	48		(As above.)
7	103	74	33	22	15	9	237	33		
8	123	62	39	18	9	6	242	28		
9	116	67	34	21	11	8	238	32		
10	86	66	38	36	14	12	226	44		
Aver.	106	66	33	24	12	8	232	33		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	200	40	14	3	4	1	257	13		
2	209	40	11	4	1	1	264	6		
3	191	43	14	11	2	0	259	11		
4	135	46	12	5	1	3	258	12		
5	129	49	29	22	20	11	229	41		
6	195	50	13	13	2	1	261	9		(As above.)
7	220	28	10	6	2	0	264	6		
8	188	47	16	8	4	2	259	11		
9	208	41	12	2	1	1	263	7		
10	199	44	15	5	3	2	268	7		
Aver.	193	43	15	7	4	2	258	12		

20-BORE, No. 9084; weight, 5lb. 7½oz.; barrels, 28in.

[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL.—Powder, 30grs.; shot, ⅞oz. (236 pellets); gas pressure, 2·22 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	40	28	21	14	18	20	103	133	1136	20·5
2	35	31	27	22	17	14	115	121	1195	23·0
3	46	45	29	20	18	15	140	96	1172	21·0
4	53	24	27	23	16	11	127	109	1167	21·0
5	48	45	28	21	20	16	142	94	1149	21·4
6	50	39	30	20	18	18	139	97	1181	22·6
7	29	43	23	22	17	22	117	119	1154	21·3
8	51	40	26	17	14	13	134	102	1172	21·8
9	55	44	25	19	19	11	143	93	1163	21·2
10	49	38	28	24	21	15	139	97	1145	20·7
Aver.	46	38	26	20	18	15	130	106	1163	21·4

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	74	37	40	20	13	9	171	65		
2	80	55	31	19	15	10	181	53		
3	102	57	24	12	16	2	195	41		
4	76	48	35	17	14	7	176	60		
5	70	50	26	24	13	12	170	66		
6	73	53	33	21	18	13	180	56		(As before.)
7	74	60	35	16	9	10	183	50		
8	83	55	27	25	11	11	190	43		
9	77	46	34	16	19	13	173	63		
10	85	60	23	20	14	8	193	43		
Aver.	79	53	31	19	14	9	181	55		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	133	73	8	4	4	0	221	15		
2	156	48	10	3	2	2	217	19		
3	115	62	8	6	1	0	191	45		
4	151	51	9	5	3	1	216	20		
5	198	25	3	3	0	0	233	13		
6	161	46	7	4	2	2	218	18		(As before.)
7	162	37	16	1	3	3	216	20		
8	149	56	11	6	4	1	222	14		
9	153	41	10	4	0	2	213	23		
10	155	52	8	5	3	2	220	16		
Aver.	154	49	9	4	2	1	216	20		

LEFT BARREL.—Powder, 36grs.; shot, 1oz. (236 pellets); gas pressure, 2·22 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	53	48	32	20	16	10	156	80		
2	38	42	27	16	11	8	123	113		
3	47	50	34	21	17	12	152	84		
4	44	42	30	23	19	8	139	97		
5	28	20	12	10	14	17	70	166		
6	50	45	33	20	15	10	148	88		(As above.)
7	53	47	36	19	18	13	154	82		
8	42	51	37	19	16	9	149	87		
9	31	33	36	21	17	16	121	115		
10	53	46	34	17	14	11	155	81		
Aver.	45	42	31	19	16	11	137	99		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	82	54	30	16	14	11	182	54		
2	86	58	33	20	12	9	197	39		
3	72	42	43	25	14	18	182	54		
4	83	64	29	17	10	10	193	43		
5	65	48	33	20	13	7	166	70		
6	88	55	32	19	11	6	194	42		(As above.)
7	84	46	34	27	13	11	191	45		
8	90	64	31	15	12	8	200	36		
9	82	61	32	33	10	6	206	28		
10	81	55	35	20	16	10	191	45		
Aver.	81	55	33	21	12	10	190	46		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	168	33	16	7	2	3	224	12		
2	172	40	10	5	3	0	227	9		
3	177	37	7	4	0	1	225	11		
4	170	45	11	3	2	2	229	7		
5	173	41	7	4	4	1	225	11		
6	176	56	8	3	3	1	233	13		(As above.)
7	164	43	19	2	2	0	233	8		
8	168	41	12	5	3	1	226	10		
9	183	39	5	2	1	0	229	7		
10	173	37	9	6	5	2	232	11		
Aver.	172	39	10	4	2	1	225	11		

20-BORE, No. 2579; weight, 5lb. 7½oz.; barrels, 26in.

Barometer, 29·41; Thermometer—Dry, 61°; Wet, 54°.

RIGHT BARREL, powder, 32grs.; shot, 1oz. (270 pellets); gas pressure, 3·18 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	33	34	27	25	18	20	119	151	1172	28·3
2	40	32	28	19	16	14	119	151	1154	27·8
3	33	29	33	17	19	18	122	149	1149	27·2
4	43	31	29	20	15	12	133	147	1167	23·3
5	35	35	15	17	16	18	102	168	1186	28·9
6	41	34	30	23	21	16	127	143	1158	27·5
7	35	36	33	20	16	11	124	146	1181	29·0
8	36	28	24	18	17	15	106	164	1163	28·6
9	39	34	31	24	20	18	128	142	1154	27·7
10	28	24	26	21	11	16	99	171	1181	28·8
Aver.	37	32	28	20	17	16	117	158	1166	28·2

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	80	66	29	28	22	9	203	67		
2	75	62	39	24	20	14	200	70		
3	82	54	30	19	18	10	185	85		
4	61	21	23	25	13	13	130	140		
5	84	60	28	21	16	11	193	77		
6	86	58	32	23	15	15	199	71		(As above.)
7	102	55	38	15	17	12	210	60		
8	63	65	38	26	13	13	192	78		
9	91	58	34	22	14	8	205	65		
10	58	33	33	26	18	15	150	120		
Aver.	78	53	32	23	17	12	186	84		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	86	52	29	20	14	11	187	83		
2	135	66	21	10	6	4	232	38		
3	84	51	42	20	24	10	197	73		
4	123	49	28	16	12	7	215	55		
5	88	58	39	12	13	9	197	73		
6	125	56	26	14	10	11	221	49		(As above.)
7	139	64	19	7	9	3	229	41		
8	108	52	24	18	13	12	202	68		
9	111	47	28	12	14	8	198	72		
10	141	62	16	9	7	5	228	42		
Aver.	114	56	27	14	12	8	211	59		

LEFT BARREL, powder, 32grs.; shot, 1oz. (270 pellets); gas pressure, 3·18 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	46	35	26	24	19	20	131	139		
2	40	29	27	18	22	19	114	156		
3	38	38	35	22	16	11	133	137		
4	33	14	20	19	7	9	85	185		
5	47	33	25	21	23	17	123	114		
6	16	15	19	15	11	6	65	205		(As above.)
7	28	36	32	22	17	15	128	142		
8	35	27	31	17	26	23	110	160		
9	14	18	12	16	10	11	60	210		
10	44	32	28	25	18	16	129	141		
Aver.	35	28	25	20	17	15	108	162		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	95	63	34	22	17	13	214	53		
2	84	55	43	19	15	17	201	69		
3	110	58	31	18	14	11	217	53		
4	69	47	36	29	16	18	181	89		
5	91	64	39	28	14	8	222	48		
6	83	59	30	21	17	12	193	77		(As above.)
7	103	66	32	26	12	9	237	43		
8	88	60	34	21	18	14	203	67		
9	40	26	21	20	13	16	107	163		
10	85	62	35	19	19	8	201	69		
Aver.	85	56	34	22	15	13	197	73		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	85	43	34	19	17	10	186	84		
2	152	45	33	14	11	6	244	26		
3	137	63	27	6	9	7	233	38		
4	161	55	16	10	5	3	242	28		
5	148	59	25	9	0	5	241	29		
6	152	41	32	15	8	4	240	30	(As before.)	
7	175	47	13	10	2	1	245	25		
8	144	56	29	9	7	7	238	32		
9	157	44	31	18	11	5	250	20		
10	168	50	18	11	9	6	247	28		
Aver...	148	51	26	12	8	5	237	33		

20-BORE, No. 2579; weight, 5lb. 7½oz.; barrels, 26in.
[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL, powder 31grs.; shot ¾oz. (236 pellets); gas pressure, 2·27 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	37	19	19	16	13	9	93	143	1163	23·8
2	33	27	25	25	18	17	110	126	1154	23·7
3	40	24	21	19	17	12	104	132	1186	24·7
4	38	29	23	26	22	11	115	121	1172	23·9
5	33	32	26	23	16	13	114	122	1158	23·0
6	20	14	14	19	29	15	67	169	1149	22·5
7	26	16	33	11	15	14	85	151	1167	23·7
8	33	30	28	24	17	17	115	121	1145	22·1
9	30	18	20	15	20	15	83	153	1163	23·5
10	18	20	24	16	14	16	78	158	1176	24·0
Aver...	31	23	23	20	18	14	97	139	1163	23·4

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	52	33	32	24	19	14	141	95		
2	66	45	29	22	23	17	162	74		
3	42	34	30	27	17	20	133	103		
4	38	27	35	25	15	15	125	111		
5	58	40	31	23	20	19	152	84		
6	35	33	25	30	18	18	123	113	(As above.)	
7	60	42	28	26	24	14	156	80		
8	59	31	32	28	15	18	150	86		
9	54	36	34	25	21	15	149	87		
10	20	18	19	16	16	16	73	163		
Aver...	48	34	29	25	19	17	136	100		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	58	72	28	20	14	10	178	53		
2	101	53	22	16	9	5	193	44		
3	77	55	28	27	17	13	187	40		
4	92	57	25	22	10	10	196	40		
5	82	48	20	29	15	16	179	57		
6	107	46	18	11	11	12	182	54	(As above.)	
7	94	55	23	21	9	3	193	43		
8	95	44	21	20	16	11	180	56		
9	114	50	14	7	8	8	185	51		
10	87	58	24	22	6	5	191	45		
Aver...	91	54	22	19	11	9	183	50		

LEFT BARREL, powder, 31grs.; shot, ¾oz. (236 pellets); gas pressure, 2·27 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	44	32	24	22	17	11	123	114		
2	19	17	24	15	23	14	75	161		
3	38	33	25	26	15	12	122	114		
4	35	37	23	23	20	18	118	118		
5	45	34	25	24	18	15	128	108		
6	20	29	13	25	11	11	87	149	(As above.)	
7	34	17	16	13	12	16	90	156		
8	41	30	27	22	19	16	126	110		
9	17	18	18	19	16	17	72	164		
10	42	37	21	21	14	10	121	115		
Aver...	33	29	22	21	16	14	105	131		

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	23	26	29	13	7	17	95	141		
2	55	47	31	25	17	16	158	78		
3	30	22	25	17	20	23	94	142		
4	59	45	37	26	16	13	167	69		
5	43	36	34	31	15	20	144	92		
6	49	43	31	25	19	15	153	83	(As before.)	
7	58	42	30	23	16	11	158	78		
8	46	45	32	26	19	13	149	87		
9	37	26	28	28	17	14	116	120		
10	51	44	33	29	22	16	157	79		
Aver...	46	38	31	24	17	16	139	97		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	96	54	34	11	12	6	195	41		
2	110	56	33	14	10	8	213	23		
3	98	60	31	16	8	6	205	31		
4	106	58	34	12	11	4	210	26		
5	117	51	32	15	7	3	215	21		
6	99	66	30	13	9	5	208	28	(As above.)	
7	97	70	35	10	12	1	219	24		
8	108	53	30	16	5	4	207	29		
9	105	54	29	14	7	9	208	34		
10	113	52	34	12	8	6	211	25		
Aver...	105	57	32	13	9	5	207	29		

("*Field*," *May* 16, 1896; *Vol.* 87, *p.* 758.)

20-BORE, No. 1405; weight, 5lb. 12oz.; barrels, 28in.
Barometer, 29·82; Thermometer—Dry, 48°; wet, 44°.

RIGHT BARREL.—Powder, 34grs.; shot, 1oz. (270 pellets); gas pressure, 3·00 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	47	30	27	23	15	11	127	143	1163	27·1
2	43	28	33	16	19	16	119	151	1176	27·0
3	39	35	30	18	14	10	122	148	1136	25·5
4	46	33	25	23	16	13	126	144	1220	29·7
5	45	27	23	20	17	13	120	150	1136	26·1
6	33	36	26	16	9	11	111	159	1158	27·2
7	33	31	23	25	17	17	112	158	1163	27·5
8	46	33	25	21	14	10	125	145	1181	28·1
9	36	32	31	19	12	13	118	153	1154	26·8
10	43	29	28	23	18	14	123	147	1149	26·3
Aver...	41	31	28	20	15	13	120	150	1163	27·1

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	44	45	28	28	31	24	145	125		
2	75	41	34	31	20	16	181	89		
3	64	43	32	23	18	14	192	103		
4	72	39	35	32	20	21	178	92		
5	58	40	36	26	22	18	160	110		
6	22	27	21	34	25	15	104	166	(As above.)	
7	73	45	33	25	21	16	176	94		
8	66	39	34	30	19	19	171	99		
9	54	35	38	24	21	21	151	119		
10	70	36	32	28	22	18	166	104		
Aver...	60	39	32	28	22	18	159	111		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	129	42	38	14	15	12	223	47		
2	97	58	36	25	13	9	216	54		
3	107	62	35	17	16	8	221	49		
4	114	64	31	18	10	5	227	43		
5	97	53	38	29	16	6	217	53		
6	120	55	32	17	11	10	224	46	(As above.)	
7	112	67	28	15	5	5	222	48		
8	117	56	30	14	9	4	217	53		
9	93	64	41	20	15	11	218	52		
10	105	69	34	18	10	7	226	44		
Aver...	109	59	34	19	12	8	221	49		

LEFT BARREL.—Powder, 34grs.; shot, 1oz. (270 pellets); gas pressure, 3·00 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	39	35	26	24	18	15	124	146		
2	36	16	28	15	15	14	95	175		
3	41	30	25	20	17	18	116	154		
4	32	28	23	21	13	11	107	163		
5	26	31	33	23	15	17	113	157		
6	36	17	23	22	14	16	98	172		(As before.)
7	10	18	13	19	17	13	60	210		
8	40	31	27	23	15	15	121	149		
9	26	31	21	21	7	19	90	171		
10	38	29	22	18	16	12	107	163		
Aver..	32	27	24	21	15	15	104	166		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	45	41	16	15	15	192	108		
2	34	27	30	33	21	21	124	146		
3	55	45	38	24	16	17	162	108		
4	49	37	33	28	20	23	147	123		
5	65	42	30	23	18	17	160	110		
6	57	40	31	25	23	20	154	116		(As above.)
7	51	36	43	31	15	14	161	109		
8	62	44	39	21	18	12	166	104		
9	54	41	25	29	22	18	159	111		
10	46	47	28	29	27	16	170	120		
Aver...	53	40	35	26	19	17	154	115		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	101	48	42	24	15	5	215	55		
2	115	52	33	18	13	4	218	52		
3	108	63	41	12	11	2	234	46		
4	95	57	43	22	14	8	217	53		
5	117	56	24	16	12	6	213	57		
6	106	64	38	15	10	4	223	46		(As above.)
7	90	46	41	41	21	13	218	52		
8	110	54	36	20	14	9	220	50		
9	91	49	42	22	12	7	204	66		
10	102	60	35	19	16	5	216	54		
Aver...	103	55	37	21	14	6	217	53		

20-BORE, No. 1405; weight, 5lb. 12oz.; barrels, 28in.

[With Smaller Charge of Shot.]

RIGHT BARREL.—Powder, 33grs.; shot, ¾oz. (236 pellets); gas pressure, 2·12 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Ft.sec.	Recoil. Ft.lb.
1	24	17	19	15	12	18	75	161	1154	21·6
2	36	26	24	18	17	14	104	132	1172	22·4
3	29	31	24	22	21	16	106	130	1181	23·0
4	34	22	20	8	13	19	84	152	1149	20·7
5	10	24	20	19	15	18	73	163	1167	22·5
6	30	27	25	22	21	17	104	133	1132	21·1
7	16	18	17	14	10	10	65	171	1176	22·3
8	25	31	20	26	16	20	102	134	1167	22·8
9	32	28	24	24	20	16	108	128	1142	20·6
10	20	16	10	13	9	5	59	177	1173	22·9
Aver...	26	24	20	18	15	15	88	148	1161	22·0

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	25	22	33	27	21	18	107	129		
2	42	34	29	4	19	14	129	107		
3	44	37	31	29	20	16	141	95		
4	51	48	30	26	19	8	155	81		
5	42	26	35	25	20	12	123	108		
6	51	45	33	23	17	10	153	84		(As above.)
7	50	38	30	28	19	17	146	90		
8	46	39	31	21	20	14	137	99		
9	54	46	32	27	16	13	159	77		
10	33	32	20	31	18	15	121	115		
Aver...	44	37	30	26	19	14	137	98		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	114	48	25	11	12	5	198	33		
2	98	53	28	15	10	4	194	42		
3	72	51	24	14	8	11	161	75		
4	118	46	27	10	5	5	201	35		
5	110	39	26	12	10	2	187	49		
6	88	57	29	20	9	6	194	42		(As before.)
7	95	60	33	14	7	4	202	34		
8	102	50	21	11	11	3	184	52		
9	68	47	19	22	8	10	156	80		
10	103	44	23	16	11	6	189	47		
Aver...	97	49	25	14	9	6	187	49		

LEFT BARREL.—Powder, 33grs.; shot, ¾oz. (236 pellets); gas pressure, 2·12 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	35	32	25	19	18	12	111	125		
2	32	26	18	13	20	17	89	147		
3	40	31	22	14	12	12	107	129		
4	34	33	17	12	16	17	96	140		
5	30	29	21	18	13	25	98	138		
6	36	36	22	16	19	16	110	126		(As above.)
7	34	28	27	13	16	11	102	134		
8	38	30	18	14	14	14	100	136		
9	32	31	28	18	15	12	109	127		
10	39	34	24	16	18	15	113	123		
Aver...	35	31	22	15	16	15	103	132		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	54	26	36	22	19	17	138	98		
2	62	43	31	25	11	9	161	75		
3	42	30	29	22	12	13	123	113		
4	59	35	27	26	17	14	147	89		
5	68	37	24	29	15	11	158	78		
6	55	33	28	24	19	15	140	96		(As above.
7	52	35	29	20	20	12	136	100		
8	58	37	35	27	18	10	157	79		
9	54	33	25	28	12	14	140	96		
10	66	40	27	21	17	13	154	82		
Aver...	57	35	29	24	16	13	145	91		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	92	59	38	18	8	5	207	29		
2	109	48	24	15	5	3	196	40		
3	101	32	35	24	12	7	192	44		
4	99	56	34	20	6	4	209	27		
5	120	37	27	13	4	2	197	39		
6	104	51	30	18	8	6	203	33		(As above.)
7	79	47	38	15	20	13	179	57		
8	128	47	25	12	7	2	206	30		
9	88	35	36	24	13	5	183	53		
10	93	54	32	16	11	4	198	38		
Aver...	101	47	32	17	9	5	197	39		

16-BORE, No. 9029; weight, 5lb. 11oz.; barrels, 30in.

Thermometer—Dry, 64°; wet, 64°. Barometer, 30·00.

RIGHT BARREL.—Powder, 33grs.; shot, 1oz. (270 pellets); gas pressure, 2·69 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10 yds.) Ft.sec.	Recoil. Ft.lb.
1	63	38	36	26	19	16	163	107	1176	26·3
2	66	42	32	29	20	18	169	101	1154	25·0
3	40	40	30	15	21	19	125	145	1154	25·7
4	65	44	33	28	18	11	170	100	1190	27·8
5	53	26	38	24	26	18	141	129	1181	27·4
6	59	49	32	27	23	20	167	103	1141	25·5
7	22	23	21	30	12	17	96	174	1172	26·7
8	48	47	37	24	18	13	156	114	1158	23·4
9	33	33	33	23	21	15	183	137	1176	27·1
10	62	45	35	25	22	18	167	103	1163	26·8
Aver...	51	39	33	26	20	16	149	121	1166	26·5

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	101	56	32	19	14	9	208	62		
2	69	68	45	25	14	14	207	63		
3	112	63	21	18	10	7	213	57		
4	94	67	36	20	13	9	217	53		
5	92	58	32	22	15	10	204	66		
6	122	64	24	17	6	4	227	43	(As before.)	
7	105	54	33	23	11	8	215	55		
8	61	46	38	25	16	11	170	100		
9	112	62	26	20	12	9	220	50		
10	98	65	30	19	14	7	213	58		
Aver...	97	60	32	21	12	9	209	61		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	153	56	8	4	0	0	220	50		
2	175	45	20	10	5	3	250	20		
3	119	46	28	15	11	13	203	62		
4	168	54	19	8	2	2	244	26		
5	192	38	6	1	3	0	237	33		
6	166	51	17	7	5	6	241	29	(As above.)	
7	155	62	24	4	3	4	245	25		
8	176	43	18	10	4	3	247	23		
9	173	40	12	13	1	0	238	32		
10	168	57	17	6	6	4	248	22		
Aver...	164	49	17	8	4	3	238	32		

LEFT BARREL.—Powder, 33grs.; shot, 1oz. (270 pellets); gas pressure, 2·69 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	72	35	33	31	21	14	171	99		
2	61	58	39	26	15	9	184	86		
3	63	47	35	18	19	15	163	107		
4	66	45	37	28	15	11	176	94		
5	53	35	34	25	23	18	147	123		
6	72	39	36	27	17	10	174	96	(As above).	
7	64	37	29	34	19	17	164	106		
8	70	40	37	23	16	11	170	100		
9	68	46	34	25	18	12	173	97		
10	60	53	42	27	10	10	182	88		
Aver...	65	43	36	26	17	13	170	100		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	116	67	33	20	13	7	236	34		
2	99	59	30	12	6	4	200	70		
3	106	63	38	23	15	10	233	40		
4	114	54	36	25	10	6	229	41		
5	113	56	33	21	12	8	243	47		
6	124	62	32	18	9	5	236	34	(As above.)	
7	111	54	29	25	10	13	219	51		
8	120	64	31	16	8	6	231	39		
9	78	48	42	29	26	9	197	73		
10	118	55	30	18	11	8	221	49		
Aver...	110	58	33	21	12	8	222	48		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	171	62	9	3	0	2	245	25		
2	176	57	15	7	2	1	255	15		
3	196	42	17	4	1	1	259	11		
4	169	59	16	6	3	2	250	20		
5	172	63	12	4	2	0	251	19		
6	188	60	10	2	1	0	260	10	(As above.)	
7	180	54	18	5	2	1	257	13		
8	172	63	11	7	1	3	253	17		
9	199	49	10	1	3	1	259	11		
10	179	58	15	4	2	0	256	14		
Aver...	180	57	13	4	2	1	254	15		

16-BORE, No. 9029; weight, 5lb. 11oz.; barrels, 30in.
[WITH SMALLER CHARGE OF SHOT.]

RIGHT BARREL.—Powder, 31grs.; shot, 7oz. (236 pellets); gas pressure, 2·25 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10yds.) Ft.sec.	Recoil. Ft.lb.
1	54	42	21	23	15	11	140	96	1149	21·0
2	49	42	33	32	21	9	156	80	1181	22·2
3	51	45	27	26	23	11	149	87	1215	22·7
4	53	41	30	29	22	13	158	83	1158	21·8
5	22	23	19	16	19	17	80	156	1176	22·4
6	46	46	28	25	20	10	145	91	1132	20·7
7	58	40	26	23	17	15	147	89	1172	21·8
8	44	48	35	30	22	13	157	79	1136	20·8
9	50	45	22	23	23	10	145	91	1210	22·5
10	48	43	35	26	18	14	158	84	1176	22·0
Aver...	47	41	28	26	20	12	142	94	1170	21·8

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	52	44	23	31	14	17	150	86		
2	92	48	34	19	13	11	193	43		
3	106	62	29	17	10	5	214	22		
4	85	53	31	14	9	10	183	53		
5	111	44	26	17	7	6	198	38		
6	90	45	30	15	12	9	180	56	(As above.)	
7	85	58	32	10	9	5	185	51		
8	103	60	25	18	11	8	226	30		
9	96	47	31	16	6	10	190	46		
10	87	43	33	20	10	5	183	53		
Aver...	91	50	29	18	10	9	188	48		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	160	26	8	4	0	0	198	33		
2	151	40	10	6	2	1	207	29		
3	166	28	7	4	3	3	205	31		
4	174	34	5	3	1	2	216			
5	177	23	7	2	4	1	208	28		
6	163	35	9	5	2	3	212	24	(As above.)	
7	165	38	8	7	2	0	218	18		
8	167	26	10	3	5	2	206	30		
9	171	30	5	4	4	0	210	23		
10	162	41	6	4	2	1	213	23		
Aver...	166	32	7	4	2	1	209	27		

LEFT BARREL.—Powder, 31grs.; shot, 7oz. (236 pellets); gas pressure, 2·25 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	64	53	36	17	13	11	170	66		
2	50	44	33	19	15	7	145	91		
3	48	43	29	15	16	8	135	101		
4	73	46	25	20	14	12	164	72		
5	62	55	35	17	10	10	169	67		
6	44	40	22	19	12	16	125	111	(As above.)	
7	68	53	33	15	11	9	189	67		
8	65	51	31	18	16	10	165	71		
9	77	41	28	22	14	15	198	68		
10	74	40	32	16	10	18	192	74		
Aver...	63	47	30	18	13	11	157	79		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	99	53	18	16	8	7	196	50		
2	116	58	21	15	10	6	210	26		
3	77	52	23	32	14	11	184	52		
4	93	56	22	18	12	9	191	45		
5	83	50	25	21	11	10	179	57		
6	108	61	26	20	13	5	215	21	(As above.)	
7	79	52	39	24	13	11	194	42		
8	92	59	25	22	10	7	198	38		
9	88	57	29	18	11	10	192	44		
10	95	55	24	20	12	8	194	42		
Aver...	93	55	25	21	11	8	194	42		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	177	30	5	2	1	2	214	23		
2	166	40	10	5	2	1	221	15		
3	180	33	8	3	0	0	224	12		
4	174	35	6	2	3	1	217	19		
5	165	38	15	7	5	2	225	11		
6	168	42	9	4	4	2	223	13		(As before.)
7	171	38	11	3	1	0	223	13		
8	175	33	6	6	0	1	219	17		
9	163	44	8	2	3	4	216	20		
10	173	37	7	5	2	2	222	14		
Aver.	171	37	8	4	2	1	220	16		

("*Field*," *May* 23, 1896; *Vol.* 87, *p.* 776.)

12-BORE, No. 40,758; weight, 5lb. 13½oz.; barrels, 27in.

Barometer, 30·06. Thermometer—Dry, 73°; wet, 73°.

RIGHT BARREL.—Powder, 35grs.; shot, 1oz. (270 pellets); gas pressure 2·55 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	48	36	33	23	17	16	140	130	1154	27·3
2	36	36	30	25	15	20	127	143	1172	28·8
3	39	20	24	23	18	24	106	164	1181	29·0
4	44	37	30	24	20	16	135	135	1158	27·0
5	41	39	33	24	22	19	138	134	1167	28·0
6	39	40	31	26	18	13	136	134	1149	27·2
7	37	33	33	28	22	15	130	140	1176	28·3
8	40	28	30	19	15	23	117	153	1181	28·0
9	43	33	29	27	20	17	137	133	1136	26·8
10	33	37	19	17	17	16	105	165	1186	29·1
Aver.	40	34	29	24	18	18	127	143	1166	27·9

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	92	48	33	25	22	17	197	73		
2	44	50	22	37	16	20	153	117		
3	89	55	20	27	21	16	191	79		
4	68	41	30	23	15	20	161	109		
5	86	57	23	23	18	14	194	76		
6	41	17	30	26	30	17	114	156		(As above.)
7	93	53	27	20	16	12	198	77		
8	81	46	40	23	20	13	190	80		
9	78	54	29	26	19	15	187	83		
10	80	52	31	24	17	18	196	74		
Aver.	76	47	29	25	19	16	177	93		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	119	43	46	31	17	10	239	31		
2	122	63	37	22	9	7	249	21		
3	133	50	31	26	7	5	240	30		
4	128	62	36	21	8	9	247	23		
5	151	60	23	11	6	0	244	26		
6	114	50	43	30	11	7	245	25		(As above.)
7	130	48	35	29	16	8	242	28		
8	124	63	33	27	7	2	250	20		
9	127	61	38	21	10	6	247	23		
10	142	53	24	21	5	4	243	27		
Aver.	129	57	34	24	10	6	244	26		

LEFT BARREL.—Powder, 35grs.; shot, 1oz. (270 pellets); gas pressure, 2·55 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	63	42	32	20	12	10	157	113		
2	53	40	30	24	18	18	150	120		
3	40	31	29	16	24	15	116	154		
4	26	23	19	23	19	21	90	180		
5	54	44	26	25	14	16	149	121		
6	57	38	34	23	19	21	152	118		(As above.)

LEFT BARREL (contd.).—Powder, 35grs.; shot, 1oz. (270 pellets); gas pressure, 2·55 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
7	53	45	36	22	15	12	156	114		
8	60	51	27	21	18	16	159	111		
9	52	43	31	29	16	19	155	115		
10	37	48	28	25	16	24	138	132		
Aver.	50	40	29	23	17	17	142	128		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	108	65	33	24	12	10	230	40		
2	121	56	30	18	11	8	235	45		
3	129	53	28	20	13	11	239	41		
4	77	53	34	19	19	14	188	87		
5	128	58	26	23	10	6	235	35		
6	106	45	30	22	22	13	208	67		(As above.)
7	130	52	27	16	15	11	235	45		
8	102	63	34	20	13	8	219	51		
9	115	60	28	23	14	10	226	44		
10	134	57	32	11	8	5	234	36		
Aver.	115	56	30	20	14	10	221	49		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	196	42	10	4	3	1	253	18		
2	201	36	12	7	1	2	256	14		
3	188	44	14	4	2	0	250	20		
4	198	40	8	6	0	1	247	23		
5	176	56	12	10	5	3	254	16		
6	203	33	10	3	3	3	249	21		(As above.)
7	194	43	9	5	6	1	251	19		
8	207	39	5	4	1	0	255	15		
9	178	50	17	7	5	0	252	18		
10	182	46	17	3	0	3	248	22		
Aver.	192	43	11	5	3	1	251	19		

12-BORE, No. 40,758; weight 5lb. 13½oz.; barrels, 27in.

[With Smaller Charge of Shot.]

RIGHT BARREL.—Powder, 34grs.; shot, ⅞oz. (236 pellets); gas pressure, 2·25 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	43	31	27	24	21	16	125	111	1128	20·4
2	35	23	25	18	10	11	101	135	1154	22·0
3	37	35	23	25	16	13	120	116	1181	24·0
4	46	34	27	23	20	17	180	106	1176	24·0
5	39	21	31	18	18	15	99	137	1128	21·3
6	41	25	21	22	23	16	109	127	1167	22·2
7	38	23	30	25	21	18	116	120	1190	24·7
8	45	20	22	21	18	17	118	118	1158	23·0
9	26	16	21	17	9	13	80	156	1172	23·4
10	40	33	28	26	21	15	127	109	1163	22·8
Aver.	39	27	24	22	18	14	112	128	1163	22·8

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	68	54	31	28	16	12	181	55		
2	66	42	28	23	11	8	159	77		
3	25	24	27	17	7	17	93	143		
4	70	56	25	20	18	11	171	65		
5	65	61	31	24	14	10	181	55		
6	56	37	27	26	21	18	146	90		(As above.)
7	68	60	32	15	11	8	175	61		
8	71	61	28	22	15	9	182	54		
9	58	42	35	25	20	12	160	76		
10	65	65	30	27	18	9	167	49		
Aver.	61	50	29	23	15	11	163	72		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	121	58	32	15	4	3	236	10		
2	106	53	35	13	5	3	207	29		
3	123	60	30	11	3	2	224	12		
4	136	51	26	14	4	0	227	9		
5	126	55	32	6	5	3	219	17		
6	97	55	35	12	7	7	199	37	(As before.)	
7	132	56	28	8	3	1	224	12		
8	128	57	27	10	4	6	222	14		
9	120	54	32	9	6	2	215	21		
10	134	49	25	12	3	1	220	16		
Aver.	122	55	30	11	4	3	218	18		

LEFT BARREL, powder 34grs.; shot 7oz. (236 pellets); gas pressure 2·25 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	48	31	24	16	12	163	73		
2	44	30	27	17	24	15	118	118		
3	56	42	35	22	19	18	155	81		
4	64	45	32	26	12	16	167	69		
5	54	47	41	23	18	14	165	71		
6	56	44	38	19	15	21	157	79	(As above.)	
7	44	36	30	28	21	17	138	98		
8	62	48	36	23	18	13	169	67		
9	59	46	33	26	20	15	164	72		
10	48	58	41	21	14	11	168	68		
Aver.	55	44	34	23	18	15	156	80		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	70	45	30	29	18	13	174	62		
2	83	65	25	15	14	11	187	49		
3	75	52	33	24	16	8	184	52		
4	81	54	31	13	14	12	179	57		
5	84	62	29	21	13	10	196	40		
6	52	50	27	15	15	11	144	92	(As above.)	
7	77	48	32	26	17	13	183	53		
8	83	65	28	28	11	4	204	32		
9	71	52	30	19	16	12	173	64		
10	88	61	26	23	12	10	198	38		
Aver.	76	55	29	21	15	10	181	55		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil
1	182	27	11	11	0	1	231	5		
2	145	41	18	8	2	9	212	24		
3	164	39	9	7	5	2	219	17		
4	188	21	14	3	2	0	226	10		
5	179	33	7	4	0	2	223	13		
6	166	46	9	7	3	0	228	8	(As above.)	
7	161	43	11	10	4	1	225	11		
8	172	39	12	11	2	2	237	9		
9	140	56	16	13	6	3	235	11		
10	181	33	10	5	3	0	229	7		
Aver.	168	37	12	8	3	2	225	11		

20-BORE, No. 41,856; weight, 5lb. 7oz.; barrels, 30in.

Barometer, 30·00. Thermometer—Dry, 71°; Wet, 71°.

RIGHT BARREL.—Powder, 33grs.; shot, 1oz. (270 pellets); gas pressure, 3·70 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	42	26	24	21	15	20	113	157	1154	26·4
2	73	32	27	24	20	16	156	114	1176	27·0
3	62	46	31	22	18	15	161	109	1141	25·0
4	64	42	33	22	16	19	161	109	1181	27·6
5	28	21	20	23	15	21	87	183	1158	26·0
6	66	42	33	21	19	14	162	108	1163	26·6
7	58	44	30	25	16	18	157	113	1149	25·8
8	71	39	28	22	13	13	160	110	1172	27·2
9	32	34	25	23	19	15	114	156	1141	25·5
10	68	45	31	20	17	12	164	106	1167	26·0
Aver.	56	37	28	22	17	16	143	126	1160	26·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	62	57	38	37	15	15	194	76		
2	58	40	40	19	12	16	157	113		
3	126	58	28	15	11	9	227	43		
4	46	24	28	30	19	28	128	142		
5	92	55	36	26	17	13	209	61		
6	103	60	33	21	12	10	215	55	(As before.)	
7	109	62	38	13	9	7	228	48		
8	68	59	40	33	13	10	200	70		
9	116	53	31	25	16	13	225	45		
10	121	56	35	18	10	7	230	40		
Aver.	90	52	35	24	13	13	201	69		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	158	63	15	6	5	4	242	23		
2	166	54	13	2	2	2	235	35		
3	155	60	11	4	1	3	230	40		
4	179	56	9	3	5	1	247	23		
5	169	47	18	6	4	3	233	37		
6	153	61	15	5	4	2	234	36	(As above.)	
7	160	58	12	6	2	1	236	34		
8	151	44	21	6	3	3	222	48		
9	156	49	19	7	5	3	231	39		
10	178	52	10	4	4	2	239	31		
Aver.	161	54	14	5	3	2	234	36		

LEFT BARREL.—Powder, 33grs.; shot, 1oz. (270 pellets); gas pressure, 3·70 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	21	21	28	12	22	15	82	188		
2	62	33	31	23	21	12	153	117		
3	51	32	33	25	13	18	141	129		
4	22	22	19	21	7	16	84	186		
5	55	40	30	26	22	17	151	119		
6	33	32	22	21	18	23	108	162	(As above.)	
7	59	37	22	28	24	22	146	124		
8	53	33	27	29	21	14	142	128		
9	33	36	31	27	20	16	132	138		
10	60	35	29	25	18	18	149	121		
Aver.	45	33	27	24	19	17	129	141		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	86	63	33	23	9	13	205	65		
2	106	62	32	20	11	8	220	50		
3	93	58	36	25	16	11	212	58		
4	101	60	32	28	13	9	221	49		
5	40	44	26	23	13	19	133	137		
6	72	51	32	30	12	13	185	85	(As above.)	
7	105	56	34	22	15	10	217	53		
8	110	65	37	17	8	7	229	41		
9	89	66	39	26	15	12	220	50		
10	114	54	33	25	12	8	226	44		
Aver.	92	58	33	24	12	11	207	63		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	183	34	8	2	5	2	227	43		
2	164	46	13	8	3	0	231	39		
3	149	60	15	10	8	1	234	36		
4	152	52	17	7	4	2	228	42		
5	188	28	8	1	0	1	220	50		
6	145	62	16	11	2	2	234	36	(As above.)	
7	146	46	18	8	3	1	218	52		
8	162	53	9	6	5	3	230	40		
9	154	55	16	5	4	0	230	40		
10	171	42	10	3	2	3	236	44		
Aver.	161	48	13	6	3	1	228	42		

20-BORE, No. 41,856; weight, 5lb. 7oz.; barrels, 30in.

RIGHT BARREL.—Powder, 31grs.; shot, ¾oz. (236 pellets); gas pressure 3·33 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10yds.) Ft.sec.	Recoil. Ft.lb.
1	46	45	28	21	16	11	140	96	1176	22·8
2	28	25	24	17	29	17	94	142	1149	21·6
3	40	44	31	30	20	12	135	111	1149	20·8
4	35	39	32	28	14	10	128	103	1141	20·4
5	25	23	21	14	5	13	83	153	1158	22·0
6	37	44	31	23	18	15	135	101	1173	21·8
7	44	36	25	19	21	11	124	112	1167	22·3
8	41	41	27	24	15	19	133	103	1154	21·1
9	23	24	23	16	17	18	85	51	1225	23·5
10	24	20	10	20	16	13	74	62	1163	22·1
Aver...	34	34	24	20	17	14	112	104	1165	21·8

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	106	52	25	21	12	4	201	35		
2	76	41	38	23	16	6	178	58		
3	109	50	26	12	3	6	197	39		
4	33	20	18	21	19	18	91	145		
5	86	46	33	20	10	5	185	51		
6	61	49	33	24	13	10	166	70	(As above.)	
7	105	53	27	16	9	3	200	36		
8	77	59	35	23	13	10	194	42		
9	82	51	29	24	15	7	186	50		
10	92	48	30	18	11	5	188	48		
Aver...	82	47	29	20	12	7	178	58		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	79	49	37	16	13	12	181	55		
2	123	53	23	11	5	3	209	27		
3	163	24	9	9	3	1	205	31		
4	117	54	20	10	7	5	201	35		
5	106	62	22	16	5	4	206	30		
6	138	50	15	8	2	1	211	25	(As above.)	
7	105	55	24	12	8	2	196	40		
8	113	49	27	14	3	3	202	34		
9	140	53	14	6	4	5	213	23		
10	101	61	25	13	6	2	200	36		
Aver...	118	51	22	11	6	4	202	34		

LEFT BARREL.—Powder, 31grs.; shot, ¾oz. (236 pellets); gas pressure, 3·33 tons per sq. inch.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	78	48	24	21	14	7	171	65		
2	43	42	28	26	18	14	139	97		
3	18	11	15	11	8	12	55	181		
4	38	38	19	19	24	13	114	122		
5	58	47	30	23	19	18	158	78		
6	18	16	14	12	15	17	60	176	(As above.)	
7	40	37	28	21	12	15	126	110		
8	29	20	17	23	17	11	89	147		
9	73	45	35	20	15	13	172	64		
10	66	48	26	25	18	16	165	71		
Aver...	46	35	24	20	16	14	125	111		

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th. ring.	5th ring.	6th. ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	73	42	41	33	12	7	187	49		
2	36	51	32	23	18	12	192	44		
3	73	45	34	26	16	11	178	58		
	26	52	19	11	11	9	177	59		
	33	49	30	20	14	13	181	55		
	37	54	22	13	10	8	176	60	(As above.)	
7	77	50	35	31	15	10	193	43		
8	61	48	23	29	11	13	161	75		
9	26	50	21	18	9	8	184	52		
10	84	46	28	21	14	11	179	57		
Aver...	81	49	29	22	13	10	181	55		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	115	49	21	11	10	4	196	40		
2	121	52	16	9	6	3	198	38		
3	104	60	30	7	3	2	201	35		
4	119	45	28	12	8	2	204	32		
5	99	58	39	10	5	4	206	30		
6	116	45	20	11	7	3	192	44	(As before.)	
7	120	40	13	1	2	1	174	62		
8	112	53	23	8	3	2	196	40		
9	119	54	25	10	6	6	208	28		
10	108	62	21	9	8	4	200	36		
Aver...	113	52	24	9	6	3	198	38		

("*Field*," *June* 6, 1896; *Vol.* 87, *p.* 859.)

WE HAVE COMPLETED the trial of the 12, 16, and 20-bore guns by carrying out the suggestion, made by a correspondent a few weeks ago, to give similar records of a 7lb. 12-bore, for purposes of comparison. The full particulars of the experiments with the 7lb. gun we now insert. The first set of tables gives the trial with 1oz. of shot; and the second, instead of stating, as in former issues, the results with a reduced charge, here gives an increase of ½oz., so as to make up 1½oz., which is the usual game charge with 12-bore guns of ordinary weight. This 7lb. gun is well defined in its boring—the right barrel being a very good cylinder, and the left a rather full choke. Ordinarily this gun gives a pattern of between 120 and 130 with the right barrel and between 170 and 200 with the left, in the 30in. circle at 40 yards—the patterns varying more or less with the nature of the powder used, and the condition of the weather at the time of trial. In the present instance, owing to the warm and very dry atmosphere, the powder was more active than it had been in the early part of these trials; and, consequently, smaller charges were required to produce the standard velocity of 1160 ft.sec. Instead of 42grs. being necessary with 1½oz. of shot, and about 38grs. with 1oz., it will be seen that the charges were reduced to 37grs. and 34grs. respectively, and yet the stress in the barrel was considerably higher than when larger charges were employed about three months ago. The great dryness, in our opinion, has more to do with the extra force exhibited, than has the mere increase of temperature; and this has long since been pointed out in the *Field* as the result of keeping cartridges in slightly warmed closets. If they remain, week after week, in a dry cupboard heated only to a temperature of about 70°, all the natural moisture in the powder is gradually abstracted, and thus some nitro powders may become more violent than if heated to 212° for a short period.

Many curious facts have been elicited by these trials, and we shall allude to some of them, as they may serve to supply information to many people who make inquiries relative to guns, and the charges that should be used with them. For instance, it is not an uncommon thing for persons to ask what is the proper charge of powder to use with a given weight of shot. Some may mention the bore of the gun and the particular kind of powder intended to be used; but others do neither; and it occurs to very few to state the length of the barrel. It need hardly be mentioned, however, that the same proportions of powder and shot will not suit all guns; and the particulars given in these trials will show that, with equal charges of shot, the powder should be reduced in guns of smaller gauge; and, on the other hand, that if the barrels are shortened, the powder should be increased.

An examination of the accompanying tables of averages will supply information on various moot points; and we have arranged the tables so as to facilitate reference. Thus, in each class, the guns are first placed in order of weight; and, when two occur of the same weight, the longest barrels take precedence. Looking at the light 12-bores, it will be seen that the first gun has 28in. barrels, while two others have barrels only 24in. in length. These short barrels required a larger charge of powder to impart equal velocity to the shot; and they also gave more recoil. Part of this increased recoil is due to the lighter weight of the gun, but another part is due to the fact that the gas rushes out of the short barrel in a less exhausted condition than when the tube is longer; hence more powder is often required to make up the deficiency in velocity. A remarkable instance of this occurred with a 16-bore, which we were very anxious to try, in consequence of the extreme shortness of its barrels, as they were only 22in. long. An immense deal of trouble was taken with this gun; the powder was increased again and again, and 2¾in. cases were substituted instead of the ordinary 2½in. shells; but all to no purpose, as the largest charge that could be got into the long case was insuffi-

HEAVY 12-BORE GUN (7lb.), WITH 1oz. AND 1⅛oz. OF No. 6 SHOT.

12-BORE:	Weight of Gun. lb. oz.	Length of Barrels.	Charge of Powder.	PATTERNS AND KILLING CIRCLES. First Barrel. 20yds. 30yds. 40yds.	Second Barrel. 20yds. 30yds. 40yds.	VELOCITY. Ft.sec.	RECOIL. Ft.lb.	STRESS. Tons.	THERM. Dry.
No. 20448 (1oz. shot)	7 0 ...	30in.	34grs.	242 ... 163 ... 124 ..... 30in. 36in. 36in.	261 ... 235 ... 174 22in. 30in. 33in.	1169	... 23·6	2·40	71°
Ditto (1⅛oz. shot)	"	"	37grs.	258 ... 185 ... 115 ..... 30in. 36in. 36in.	296 ... 250 ... 168 22in. 33in. 36in.	1163	... 29·6	3·22	71°

LIGHT-WEIGHT 12-BORES, WITH 1oz. OF No. 6 SHOT.

12-BORES:	Weight of Gun. lb. oz.	Length of Barrels.	Charge of Powder.	PATTERNS AND KILLING CIRCLES. First Barrel. 20yds. 30yds. 40yds.	Second Barrel. 20yds. 30yds. 40yds.	VELOCITY. Ft.sec.	RECOIL. Ft.lb.	STRESS. Tons.	THERM. Dry.
No. 5466	5 13½ ...	28in.	38grs.	216 ... 192 ... 115 ..... 30in. 33in. 36in.	221 ... 199 ... 123 3 in. 36in. 36in.	1152	... 27·3	1·38	48°
" 40758	5 13½ ...	27in.	35grs.	244 ... 177 ... 127 ..... 30in. 30in. 36in.	251 ... 221 ... 142 22in. 30in. 36in.	1166	... 27·9	2·55	73°
" 1072	5 12½ ...	26in.	39grs.	217 ... 166 ... 100 ..... 30in. 36in. 36in.	237 ... 166 ... 111 30in. 3.in. 36in.	1174	... 28·3	1·52	59°
" 2502	5 4 ...	24in.	40grs.	212 ... 157 ... 109 ..... 30in. 33in. 33in.	225 ... 212 ... 141 30in. 30in. 33in.	1156	... 30·5	1·81	46°
" 7255	5 3 ...	26in.	37grs.	207 ... 180 ... 147 ..... 2 in. 33in. 33in.	226 ... 198 ... 150 26in. 33in. 36in.	1163	... 29·0	1·67	53°
" 1906	4 14 ...	24in.	40grs.	226 ... 160 ... 106 ..... 30in. 36in. 36in.	230 ... 214 ... 170 26in. 30in. 36in.	1159	... 32·7	1·79	50°

16-BORE GUNS, WITH 1oz. OF No. 6 SHOT.

16-BORES:	Weight of Gun. lb. oz.	Length of Barrels.	Charge of Powder.	PATTERNS AND KILLING CIRCLES. First Barrel. 20yds. 30yds. 40yds.	Second Barrel. 20yds. 30yds. 40yds.	VELOCITY. Ft.sec.	RECOIL. Ft.lb.	STRESS. Tons.	THERM. Dry.
No. 2961	6 0 ...	29in.	36grs.	242 ... 171 ... 122 ..... 30in. 36in. 33in.	247 ... 186 ... 130 30in. 30in. 36in.	1169	... 26·1	2·66	63°
" 854	5 15 ...	28in.	36grs.	219 ... 204 ... 157 ..... 26in. 33in. 36in.	227 ... 198 ... 163 26in. 30in. 36in.	1165	... 25·0	2·46	51°
" 7330	5 12 ...	26in.	35grs.	231 ... 150 ... 113 ..... 30in. 36.n. 36in.	237 ... 183 ... 145 26in. 33in. 36in.	1167	... 27·9	2·61	61°
" 9029	5 11 ...	30in.	33grs.	238 ... 209 ... 149 ..... 26in. 30in. 36in.	254 ... 222 ... 170 22in. 30in. 33in.	1166	... 26·5	2·69	64°
" 1801	5 8½ ...	27in.	37grs.	199 ... 164 ... 103 ..... 33in. 36in. 39in.	226 ... 145 ... 103 33in. 36in. 39in.	1162	... 27·6	2·64	58°
" 3794	5 5½ ...	28in.	36grs.	218 ... 147 ... 110 ..... 30in. 36in. 36in.	219 ... 141 ... 121 30in. 36in. 36in.	1160	... 28·4	2·51	48°

20-BORE GUNS, WITH 1oz. OF No. 6 SHOT.

20-BORES:	Weight of Gun. lb. oz.	Length of Barrels.	Charge of Powder.	PATTERNS AND KILLING CIRCLES. First Barrel. 20yds. 30yds. 40yds.	Second Barrel. 20yds. 30yds. 40yds.	VELOCITY. Ft.sec.	RECOIL. Ft.lb.	STRESS. Tons.	THERM. Dry.
No. 2365	5 15½ ...	30in.	32grs.	246 ... 193 ... 129 ..... 26in. 33in. 36in.	255 ... 205 ... 142 26in. 33in. 36in.	1170	... 24·1	3·06	58°
" 1012	5 13½ ...	29in.	32grs.	232 ... 168 ... 102 ..... 30in. 33in. 30in.	247 ... 178 ... 134 33in. 33in. 26in.	1178	... 26·4	3·06	55°
" 1405	5 12 ...	28in.	34grs.	217 ... 154 ... 104 ..... 30in. 36in. 36in.	221 ... 159 ... 120 30in. 36in. 36in.	1163	... 27·1	3·00	48°
" 1043	5 10 ...	27in.	33grs.	202 ... 142 ... 94 ..... 36in. 36in. 33in.	215 ... 153 ... 95 36in. 33in. 30in.	1177	... 28·2	3·13	55°
" 9084	5 7½ ...	28in.	32grs.	251 ... 218 ... 147 ..... 26in. 30in. 36in.	258 ... 232 ... 165 26in. 30in. 33in.	1161	... 26·3	3·11	55°
2579	5 7½ ...	26in.	32grs.	211 ... 186 ... 117 ..... 26in. 33in. 36in.	237 ... 197 ... 108 26in. 33in. 36in.	1166	... 25·2	3·18	61°
" 41856	5 7 ...	30in.	33grs.	228 ... 207 ... 129 ..... 22in. 30in. 36in.	234 ... 201 ... 143 22in. 30in. 36in.	1160	... 26·3	3·70	71°
" 6330	5 5½ ...	28in.	30grs.	251 ... 191 ... 113 ..... 26in. 33in. 36in.	249 ... 174 ... 131 26in. 33in. 36in.	1172	... 29·3	3·03	45°
" 10162	5 4½ ...	28in.	36grs.	214 ... 130 ... 100 ..... 33in. 36in. 36in.	248 ... 138 ... 95 30in. 36in. 33in.	1138	... 28·6	3·03	50°

cient to bring the velocity up to the standard, and therefore the trial of this gun was abandoned.

As regards the proportions of powder and shot to be used, it is not easy to lay down definite lines, owing to the variations among nitro powders. With black powder, such as No. 4, a very fair proportion is 1 to 6; and as there are 18 drams in 1½oz. of shot, 3drs. of black powder is a suitable proportion. With the older nitro powders, which are about half the specific gravity of black powder, the proportion should be about 1 to 12; so that, as 1½oz. of shot is equal to 492 grains and a fraction, 41 or 42 grains of these old nitro powders closely accord with that proportion. With the new concentrated powders the proportions vary too much to admit of any very definite statement. But what is stated above would only apply to barrels about 30in. long; and, as the tables show, reduction in length of barrel requires an increase in the proportion of powder.

With regard to matters which will not be apparent from the tables, we may mention that *full*-chokes often throw the charge off the centre of the target; and light guns, the "hands" of which are small, throw the charge low, owing to the springing of the stock. Short barrels, besides requiring more powder, and giving more recoil, also make more noise, and quickly produce headache. We take it that from 28 to 30 inches is a good length for either 12, 16, or 20-bores; and we doubt the advantage of shortening the barrel much below 28in.

It will be seen that the narrower the bore, the higher is the stress in the barrel; but it does not follow that the stress is dangerous; because the smaller the gauge, the less is the area for the pressure to act upon, and the strength of barrel would thus be relatively greater—other conditions being equal. We think, however, that ¾oz. charge is the maximum that should be used for 20-bores. For 1oz. we should prefer a 16-bore or a light 12-bore—both of which, as is shown by the accompanying tables, can be made as light as the 20-bores that have here undergone trial.

At the present time, however, we do not give particulars relative to the experiments with the ¾oz. charge of shot. These we propose to summarise in a subsequent article.

Referring to the records of "patterns" and "killing circles," with the guns of different bore, at ranges of 20, 30, and 40 yards, it will be seen that we have grouped them together, by stating, immediately below each numerical pattern, the greatest spread of the shot that can, by any reasonable interpretation, be said to constitute a "killing circle." Each ring on the plate covers a space equivalent to 225 circular inches; and, unless there are at least 15 pellets within the ring (*i.e.*, an average of 15 circular inches to each pellet, or nearly 4 inches apart in every direction) the chances of killing a bird are too remote to be relied upon; as such a distribution would only be equivalent to an evenly-distributed pattern of 60 pellets in a 30in. circle. And, by referring to the tables of results, it will be seen that some of the cylinder barrels scattered the charge so broadly at 40 yards that the "killing circle" was several inches less than it had been at 30 yards,—the greater portion of the pellets being so widely separated as to be practically useless. (In employing the word "cylinder," we do so in the conventional sense of a gun that is not sufficiently altered in the boring to be considered a choke; but, in fact, no truly cylindrical tube is sent out in a finished gun. All barrels are "touched up" more or less.)

For general purposes a cylinder barrel cannot be relied upon beyond 30 yards, especially if the charge is less than 1½oz. With this charge of No. 6, a "good cylinder" should give a pattern of from 125 to 130 pellets in the 30in. circle at 40 yards. Taking 126, as a number that will readily divide without fractions, the corresponding pattern with 1oz. of shot in the same barrel should be 14 less, or a pattern of 112; and with ¾oz. of shot, it should be further diminished by 14, so that the pattern would be 98. It will be seen by the accompanying tables that some of the barrels in these trials gave patterns below 100 with 1oz. of shot; and, of course, still lower numbers were given with ¾oz. Now, in our opinion, a gun that has both barrels cylinders, with these small charges, is of comparatively little use at distances much beyond 30 yards, owing to the pellets being so wide apart; and we think that the second barrel ought to be moderately choked. On the other hand, we consider it undesirable to have both barrels fully choked; as, if so, the pattern at 20 yards has then so little spread that, unless you are "dead on" your bird, the chances of missing altogether are very considerable; while, if you are "dead on," the bird will not be pleasant to chew. Accordingly, we should prefer a good cylinder or slight choke for the first barrel, and a medium or full choke for the second.

We have used the words "First Barrel" and "Second Barrel" instead of "Right" and "Left," on the supposition that the most closely choked barrel would be used last; but in some instances the two barrels are so very nearly alike that it is difficult to distinguish between them.

As regards the proportional number of pellets in the circles at different distances, we may mention that if the charges of shot were quite evenly distributed, the number of pellets in the 30in. circle at 40 yards should be exactly the same as in the first or 15in. ring at 20 yards; and this first ring at 40 yards should contain just one fourth of the number of pellets in the same ring at 20 yards. By comparing the figures in records of the 7lb. 12 bore, it will be seen that they come approximately close with the 1½oz. charge. With the cylinder barrel, the average number of pellets in the 30in. circle, at 40 yards, was 133, and one-fourth of that number would be 33 and a fraction; while the actual number of pellets in the 1st ring at 20 yards averaged 89. Again, with the choked barrel, the average in the 30in. circle was 238, giving within a fraction of 60 when divided by 4; and the actual average was 63. With some of the guns, however, especially 20-bores, where the barrels are much choked, the tables previously published have shown a much larger proportion of pellets concentrated in the centre of the target at the 20 yards distance.

Although we give the velocities recorded with each gun, they may for all practical purposes be considered to be equal throughout, as the variations are due to slight differences in caps, powder, temperature, &c., that cannot be controlled. But it will be seen that these slight variations in velocity are usually accompanied by variations in recoil likewise. We may add that, where the temperatures are given in *italic* figures, they intimate that the records were not taken by us at the time of the trials, but they are stated as nearly as we can estimate them from published reports. The addition of meteorological records was an after-thought, brought about by the variation of results exhibited as the weather changed. But we give in this summary only the temperature taken by the dry bulb thermometer, as the addition of the wet bulb and barometric records would produce too much complication. We may mention, however, that where—as with the trials of the 7lb. gun, given in the table below—the reading of the wet bulb thermometer is much below that of the dry bulb (viz., "Dry 71°, Wet 61°"), it indicates that evaporation was going on very rapidly; and the powder would thus become dry much sooner than when (as stated in the report published on a previous page) the record appeared as "Dry 64°, Wet 64°."

12-BORE, No. 20,448; weight, 7lb.; barrels, 30in.

Barometer, 29·62. Thermometer—Dry, 71°; Wet, 61°.

RIGHT BARREL.—Powder, 34grs.; shot, 1oz. (270 pellets); gas pressure, 2·40 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	43	35	32	24	19	15	134	136	1136	22·0
2	32	24	23	18	14	20	97	173	1141	22·8
3	45	36	35	21	22	18	137	133	1195	24·8
4	42	28	24	25	20	14	119	151	1133	23·2
5	39	34	30	18	18	14	121	149	1195	24·3
6	35	36	24	23	17	19	118	152	1154	23·6
7	48	32	29	25	15	12	134	136	1190	25·0
8	36	34	28	22	20	16	120	150	1141	22·5
9	40	36	30	26	18	17	132	138	1181	24·0
10	45	31	33	20	18	23	129	141	1176	23·4
Aver...	40	33	29	22	18	17	124	146	1169	23·6

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	68	49	37	25	26	14	179	91		
2	73	46	33	27	20	17	176	92		
3	30	39	34	25	23	22	127	143		
4	61	57	36	27	20	19	181	89		
5	64	45	38	20	27	13	167	103		
6	75	43	33	25	23	17	175	95	(As above.)	
7	38	54	35	28	9	13	155	115		
8	63	47	41	26	21	16	177	93		
9	70	53	33	24	19	18	180	90		
10	26	33	36	13	24	21	108	162		
Aver...	57	46	36	24	21	17	163	107		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil
1	116	62	29	16	8	7	223	47		
2	141	66	32	18	6	4	257	13		
3	120	64	34	21	9	6	239	31		
4	132	59	37	22	7	2	250	20		
5	147	61	30	14	6	1	258	18		
6	128	56	35	19	7	7	238	32	(As above.)	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
7	130	66	25	10	11	3	241	29	
8	142	62	28	18	9	5	250	20	
9	132	58	36	14	4	2	240	30	
10	126	65	26	20	7	3	237	33	
Aver...	131	62	31	18	7	4	242	23	

LEFT BARREL.—Powder, 34grs.; shot, 1oz. (270 pellets); gas pressure, 2·40 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	50	42	50	29	20	18	171	99	
2	78	44	32	25	20	15	179	91	
3	59	61	40	23	17	15	183	87	
4	62	50	33	14	20	11	162	103	
5	74	58	43	16	13	13	191	79	
6	35	43	25	28	21	18	131	133	(As before.)
7	61	55	38	22	16	11	176	94	
8	70	67	42	18	11	14	197	73	
9	66	45	31	21	18	16	166	104	
10	73	60	35	21	15	12	189	81	
Aver...	63	52	37	22	17	14	174	96	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	114	71	16	22	6	12	223	47	
2	122	67	33	17	8	5	239	31	
3	130	53	30	19	13	7	232	38	
4	137	65	23	15	7	3	245	25	
5	105	53	39	20	15	5	217	53	
6	140	62	23	18	8	7	243	27	(As above.)
7	126	59	34	22	10	8	241	29	
8	138	66	26	16	5	4	246	24	
9	133	54	32	21	9	6	240	30	
10	102	60	36	17	6	4	215	55	
Aver...	125	61	30	19	9	6	235	35	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	225	28	11	1	0	0	265	5	
2	219	24	15	4	2	0	262	8	
3	199	30	20	6	1	2	255	15	
4	233	20	8	3	2	1	264	6	
5	204	36	12	6	3	0	258	12	
6	231	17	10	4	2	2	262	8	(As above.)
7	208	34	12	7	1	1	261	9	
8	220	24	16	3	1	0	263	7	
9	242	15	5	2	0	2	264	6	
10	200	34	18	5	3	0	257	13	
Aver...	218	26	13	4	1	1	261	9	

12-BORE, No. 20,448; weight, 7lb.; barrels, 30in.

WITH LARGER CHARGE OF SHOT, VIZ. 1⅛OZ.

RIGHT BARREL, powder 37grs.; shot 1⅛oz. (304 pellets); gas pressure, 3·22 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	46	30	25	23	18	15	124	180	1167	29·3
2	33	26	20	14	13	13	92	212	1181	30·0
3	42	30	23	20	15	19	115	189	1158	28·6
4	38	28	21	21	17	11	108	196	1163	29·8
5	44	35	31	25	14	12	135	169	1136	29·5
6	36	38	26	20	18	17	120	184	1181	30·4
7	28	27	19	22	16	23	96	208	1172	30·2
8	41	24	22	19	17	16	106	198	1154	28·8
9	33	34	36	20	16	17	123	181	1149	29·0
10	45	32	29	24	15	14	130	174	1172	30·1
Aver...	39	30	25	21	16	16	115	189	1163	29·6

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	74	53	39	25	24	15	191	113	
2	61	53	44	30	19	16	187	117	
3	69	49	35	29	22	18	182	122	
4	71	55	37	31	16	11	194	110	
5	65	50	36	36	22	13	187	117	(As before.)
6	72	54	33	25	20	16	184	120	
7	68	46	38	18	16	25	170	134	
8	77	53	35	27	19	17	191	113	
9	59	50	34	34	21	14	177	127	
10	71	58	32	23	17	15	183	121	
Aver...	69	52	36	28	20	16	185	119	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	112	64	38	22	12	13	236	68	
2	143	66	32	19	15	11	280	44	
3	121	76	48	24	15	9	269	35	
4	132	67	39	15	12	5	253	51	
5	145	68	27	17	19	8	257	47	
6	140	75	31	20	16	6	288	38	(As above.)
7	123	73	41	16	13	10	252	52	
8	135	74	35	18	15	9	262	42	
9	138	67	42	13	11	6	280	44	
10	141	71	28	22	17	12	280	44	
Aver...	133	70	36	19	14	9	258	46	

LEFT BARREL, powder 37grs.; shot 1⅛oz. (304 pellets); gas pressure, 3·22 tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	62	36	45	36	23	13	179	125	
2	35	27	31	22	22	16	115	189	
3	56	40	28	22	19	25	146	158	
4	75	58	30	23	20	13	186	118	
5	68	44	33	20	19	19	165	139	
6	64	41	35	29	15	14	169	135	(As above.)
7	76	60	32	25	31	11	193	111	
8	59	45	27	21	21	15	152	152	
9	63	51	34	31	18	16	182	122	
10	73	64	36	24	22	13	197	107	
Aver...	63	47	33	25	21	15	163	126	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	94	62	49	32	25	20	237	67	
2	143	73	26	18	13	9	259	45	
3	139	65	37	20	18	11	261	43	
4	120	57	35	24	10	12	236	68	
5	131	69	40	22	16	10	262	42	
6	136	73	39	12	11	5	259	45	(As above.)
7	145	71	21	20	11	7	257	47	
8	129	74	32	16	14	11	251	53	
9	62	68	44	32	28	16	206	98	
10	147	70	26	22	15	8	265	39	
Aver...	125	68	35	22	16	11	250	54	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Recoil.
1	236	44	15	2	0	1	297	7	
2	243	38	9	4	1	3	299	5	
3	231	40	14	6	3	1	291	13	
4	233	43	17	3	0	0	295	9	
5	243	39	11	5	1	3	302	6	
6	236	40	10	7	5	0	293	11	(As above.)
7	230	45	16	5	2	2	296	8	
8	239	47	7	2	0	1	295	9	
9	244	33	15	6	2	0	298	6	
10	235	43	13	3	4	1	294	10	
Aver...	238	41	13	4	2	1	296	8	

("*Field*," *June* 18, 1896; *Vol.* 87, *p.* 902.)

THE RESULTS obtained with 1oz. charges have been already summarised; and we here give corresponding tables relative to the reduced or ⅞oz. charges. But even in this compact form it is not easy to follow all the variations, because some of the barrels have been cylinders, others slightly choked, and others, again, varying from medium to full chokes; while some guns have had both barrels very nearly the same, whereas others have combined two varieties of boring.

We have accordingly thought it desirable to compile some additional tables, whereby it may be seen at a glance how the respective guns compare with one another, as to being choked or otherwise; and likewise how the guns of different gauges bear comparison with one another in this respect, as well as with regard to the killing circles.

The first of these compilations, given below, shows that of six light 12-bores, the one at the top of the list (where, as in previous tables, the guns are arranged according to weight), No. 5466, has a cylinder first barrel and the second barrel slightly choked; whereas the next gun is slightly choked in the first, and more choked in the

REDUCED CHARGE OF SHOT.

12-BORE GUNS, WITH ⅞oz. OF No. 6 SHOT.

12-Bores:	Weight of Gun. lb. oz.	Length of Barrels.	Charge of Powder.	Patterns and Killing Circles. First Barrel. 20yds. / 30yds. / 40yds.	Second Barrel. 20yds. / 30yds. / 40yds.	Velocity. Ft.sec.	Recoil. Ft.lb.	Stress. Tons.	Temp. Dry.
No. 5466	5 13½	28in.	37grs.	177 / 141 / 106 (30in. / 33in. / 30in.)	189 / 156 / 110 (30in. / 33in. / 33in.)	1152	22·5	1·23	48°
„ 40758	5 13½	27in.	34grs.	218 / 163 / 112 (30in. / 33in. / 33in.)	225 / 181 / 156 (22in. / 33in. / 36in.)	1162	22·8	2·25	73°
„ 1072	5 12½	26in.	33grs.	203 / 153 / 102 (33in. / 33in. / 36in.)	202 / 153 / 114 (30in. / 33in. / 33in.)	1168	23·4	1·43	59°
„ 2052	5 4	24in.	33grs.	202 / 138 / 105 (30in. / 33in. / 36in.)	203 / 175 / 123 (26in. / 33in. / 36in.)	1161	26·3	1·43	46°
„ 7255	5 3	26in.	33grs.	207 / 189 / 147 (26in. / 30in. / 33in.)	226 / 188 / 150 (22in. / 30in. / 30in.)	1165	24·5	1·48	53°
„ 1906	4 14	24in.	33grs.	205 / 138 / 95 (30in. / 33in. / 33in.)	208 / 183 / 140 (26in. / 30in. / 36in.)	1164	27·0	1·25	50°

16-BORE GUNS, WITH ⅞oz. OF No. 6 SHOT.

16-Bores:	Weight of Gun. lb. oz.	Length of Barrel.	Charge of Powder.	Patterns and Killing Circles. First Barrel. 20yds. / 30yds. / 40yds.	Second Barrel. 20yds. / 30yds. / 40yds.	Velocity. Ft.sec.	Recoil. Ft.lb.	Stress. Tons.	Temp. Dry.
No. 1861	6 0	29in.	34grs.	207 / 152 / 100 (30in. / 33in. / 36in.)	219 / 158 / 116 (26in. / 33in. / 36in.)	1168	22·7	1·25	63°
„ 854	5 15	28in.	35grs.	208 / 186 / 137 (26in. / 30in. / 36in.)	205 / 179 / 146 (26in. / 30in. / 33in.)	1161	21·7	1·21	51°
„ 7330	5 12	26in.	34grs.	208 / 155 / 110 (30in. / 33in. / 36in.)	214 / 172 / 130 (26in. / 33in. / 30in.)	1165	23·7	1·25	61°
„ 9029	5 11	30.n.	31grs.	209 / 188 / 142 (26in. / 30in. / 36in.)	220 / 194 / 157 (22in. / 30in. / 33in.)	1170	21·8	2·25	64°
„ 1501	5 8½	27in.	36grs.	184 / 146 / 75 (33in. / 36in. / 30in.)	204 / 142 / 88 (30in. / 33in. / 33in.)	1160	23·3	1·29	58°
„ 3794	5 5½	28in.	35grs.	193 / 144 / 102 (30in. / 36in. / 33in.)	205 / 156 / 111 (30in. / 36in. / 36in.)	1160	24·0	1·21	48°

20-BORE GUNS, WITH ⅞oz. OF No. 6 SHOT.

20-Bores:	Weight of Gun. lb. oz.	Length of Barrel.	Charge of Powder.	Patterns and Killing Circles. First Barrel. 20yds. / 30yds. / 40yds.	Second Barrel. 20yds. / 30yds. / 40yds.	Velocity. Ft.sec.	Recoil. Ft.lb.	Stress. Tons.	Temp. Dry.
No. 2365	5 15½	30in.	30grs.	207 / 168 / 134 (26in. / 30in. / 33in.)	219 / 186 / 130 (26in. / 30in. / 33in.)	1169	19·6	2·14	58°
„ 1013	5 13½	29in.	30grs.	213 / 160 / 126 (30in. / 36in. / 30in.)	214 / 207 / 146 (26in. / 30in. / 33in.)	1177	21·2	2·14	55°
„ 1405	5 12	28in.	33grs.	217 / 154 / 104 (26in. / 33in. / 36in.)	221 / 159 / 120 (30in. / 33in. / 36in.)	1161	22·0	2·12	48°
„ 1043	5 10	27in.	31grs.	205 / 157 / 107 (30in. / 36in. / 30in.)	203 / 167 / 116 (33in. / 33in. / 30in.)	1180	21·7	2·20	55°
„ 9094	5 7½	28in.	30grs.	216 / 151 / 130 (22in. / 30in. / 36in.)	225 / 190 / 137 (22in. / 30in. / 33in.)	1163	21·4	2·22	55°
„ 2579	5 7½	26in.	31grs.	196 / 133 / 97 (30in. / 33in. / 30in.)	207 / 139 / 105 (26in. / 36in. / 33in.)	1163	23·4	2·27	61°
„ 41856	5 7	30in.	31grs.	198 / 181 / 125 (26in. / 30in. / 36in.)	202 / 178 / 112 (26in. / 30in. / 33in.)	1165	21·8	3·33	71°
„ 6330	5 5½	28in.	35grs.	209 / 178 / 140 (26in. / 30in. / 36in.)	213 / 184 / 141 (26in. / 30in. / 30in.)	1167	23·3	2·41	45°
„ 10162	5 4½	28in.	35grs.	198 / 129 / 98 (30in. / 36in. / 36in.)	202 / 145 / 93 (30in. / 33in. / 36in.)	1164	22·9	2·41	50°

second; the third has both barrels cylinders; the fifth both barrels full chokes, and so on.

On looking down the columns, moreover, it may be seen how the guns of different gauge compare with one another in the respective grouping; and it will be observed how very closely they often run together. On the other hand, some rather curious differences may occasionally be traced. For instance, it does not follow, because two barrels give nearly identical results at 40 yards, that there is similar regularity at other distances; nor does a choked barrel always give a larger pattern at 20 yards than a cylinder barrel at the same distance, although it may give 50 per cent. higher pattern at 40 yards. See, for instance, these two barrels among the 16-bores:

	20 yards.	30 yards.	40 yards.
No. 1801.—Cylinder Barrel.....	226	145	103
No. 854.—Full Choke.....	227	198	163

Somewhat similar instances may likewise be found among the 12 and 16 bores, by looking over the figures in the following table:

PATTERNS OF LIGHT 12-BORES, WITH 1oz. SHOT.

Gun.	Cylinder.			Slight Choke.			Fuller Choke.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
No. 5466.....	216	192	115	221	169	123	—	—	—
,, 40758.....	—	—	—	244	177	127	251	221	142
,, 1072.....	217 227	166 166	100 111	—	—	—	—	—	—
,, 2052.....	213	157	109	225	212	140	—	—	—
,, 7255.....	—	—	—	—	—	—	207 226	189 188	147 150
,, 1906.....	226	160	106	—	—	—	230	214	170

PATTERNS OF 16-BORES, WITH 1oz. SHOT.

No. 2861.....	—	—	—	242 247	171 186	122 130	—	—	—
,, 854.....	—	—	—	—	—	—	219 227	204 198	157 163
,, 7330.....	231	150	113	—	—	—	237	182	145
,, 9029.....	—	—	—	—	—	—	233 254	209 222	149 170
,, 1801.....	199 226	164 145	103 103	—	—	—	—	—	—
,, 3794.....	218	147	110	219	141	121	—	—	—

PATTERNS OF 20-BORES, WITH 1oz. SHOT.

No. 2365.....	—	—	—	246	193	129	255	205	142
,, 1013.....	232	168	102	247	178	134	—	—	—
,, 1405.....	217	154	104	221	150	120	—	—	—
,, 1043.....	202 215	142 153	94 95	—	—	—	—	—	—
,, 9084.....	—	—	—	—	—	—	251 258	218 232	147 165
,, 2579.....	237	197	108	211	186	117	—	—	—
,, 41356.....	—	—	—	228	207	129	234	201	148
,, 6830.....	—	—	—	251 249	191 174	118 131	—	—	—
,, 10162.....	214 228	130 138	100 95	—	—	—	—	—	—

We have not thought it necessary to go into the same amount of detail with the ¾oz. charge of shot; but it occasionally happens that guns make rather larger patterns with a reduced charge, in like manner as the heavy 12-bore, in the next table, shows, with 1oz. of shot, rather higher numbers (in the 30in. circle at 40 yards) than it does with 1⅛oz.; but with this increase of pattern there is occasionally a diminution in size of the killing circle. The next table summarises the whole of the guns of the three bores, and shows the average pattern and average killing circle with each group of barrels.

As a general conclusion we may say that we think there is very little difference in the results of the shooting of the various bores when the barrels are equally well regulated and the weight of the gun is suitably proportioned to the charge used therein. It is, in our opinion, a mistake to have a gun made with exceedingly short barrels, as you must either submit to a low velocity in the shot or use a larger amount of powder, which is productive of more recoil and louder report. If velocity is reduced, there must be greater allowance made in firing at game, or you will shoot behind; and the striking force of the pellets will be less, although not diminished in the same proportion as the falling off in the chronograph records. An idea of the difference in energy or striking force may be obtained by referring to particulars given on page 52.

GENERAL SUMMARY OF PATTERNS AND KILLING CIRCLES.

The number of barrels of which each group of guns consists is stated in the columns hereafter given. Thus, there were six light 12-bores tried, or twelve barrels; and of these barrels five were classed as cylinders, giving, with the 1oz. charge, patterns not exceeding 115 at 40 yards; those classed as slightly choked gave more than 115 and not exceeding 140; while those more fully choked exceeded 140. In this summary we have included the ¾oz. charge, and classed the guns in the same positions as they held with the 1oz. charge. There is generally a little reduction in the killing circle, as will be seen by comparing the figures in the last table with those of the 1oz. charge.

HEAVY 12-BORE (7lb.), WITH 1⅛oz. AND 1oz. CHARGES.

	Cylinder Barrel.			Choked Barrel.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
1⅛oz. CHARGE:						
Pattern 258	185	115	...	296	250	168
Circle... 30in.	36in.	36in.	...	22in.	33in.	36in.
1oz. CHARGE:						
Pattern 242	163	124	...	261	235	174
Circle... 30in.	36in.	36in.	...	22in.	30in.	33in.

12, 16, AND 20-BORES, WITH FULL (1oz.) CHARGES.

	Cylinder.			Slight Choke.			Fuller Choke.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
Light 12-Bores (5 barrels):				(3 barrels)			(4 barrels)		
Pattern 220	168	106		230	183	130	229	203	153
Circle... 30in.	35in.	35in.		30in.	32in.	35in.	25in.	31in.	35in.
16-Bores (4 barrels):				(3 barrels)			(5 barrels)		
Pattern 218	151	107		236	166	124	235	203	157
Circle... 31in.	36in.	37in.		30in.	33in.	34in.	28in.	32in.	35in.
20-Bores (7 barrels):				(7 barrels)			(4 barrels)		
Pattern 221	155	100		236	184	125	249	214	149
Circle... 32in.	35in.	33in.		27in.	33in.	35in.	25in.	31in.	35in.

12, 16, AND 20-BORES, WITH REDUCED (¾oz.) CHARGES.

	Cylinder.			Slight Choke.			Fuller Choke.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
Light 12-Bores:									
Pattern 195	145	104		208	164	116	216	185	148
Circle... 31in.	33in.	34in.		29in.	33in.	34in.	24in.	31in.	34in.
16-Bores:									
Pattern 199	148	95		213	163	119	210	187	143
Circle... 31in.	34in.	33in.		27in.	34in.	34in.	25in.	30in.	34in.
20-Bores:									
Pattern 202	143	101		206	171	118	214	163	135
Circle... 29in.	34in.	33in.		29in.	31in.	34in.	25in.	31in.	33in.

PHOTOGRAPHS OF GUN PATTERNS.

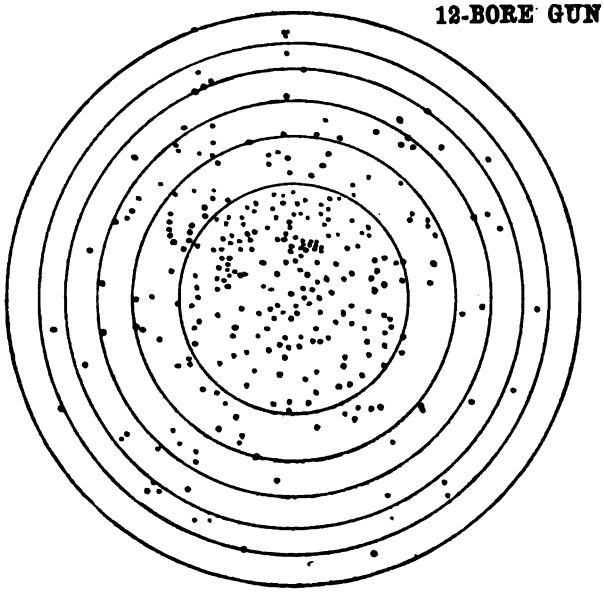
12, 16, AND 20 BORES.

On the following pages we give copies of twelve photographs representing patterns made by the right and left barrels of 12, 16, and 20 bore guns at ranges of 20 yards and 40 yards. Of course they can only be taken as generally representative of the results given by the respective guns; because, in all probability, no two patterns from the same barrel have been exactly alike, while 120 rounds have been fired from each of the guns, of which complete records have already been published.

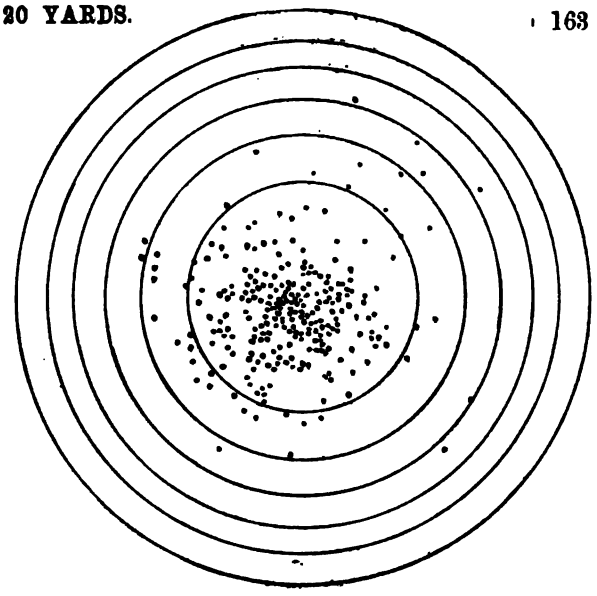
By running the eye down the page, and comparing the three illustrations under one another (as, for instance, those numbered 1, 5, and 9), one sees at a glance the results shown by the three guns under similarity of condition, except that the 20-bore has an eighth of an ounce less shot. On the other hand, by looking at the patterns side by side (*i.e.*, to numbers 5 and 6, 9 and 10, and so on), one sees the performances of the same gun, with right and left barrel, at the same distance. The circles will likewise show how differently two barrels may throw the charge—fig. 1 being very different from fig. 2; and, if anyone cares to count the pellets within the respective rings, he will see how much the patterns vary at equal distances from the centre of the target.

It will be seen that there are six rings on the target: and the fourth is the 30in. circle usually adopted by gunmakers in testing their guns. The inner circle is 15 inches in diameter; and each of the belts surrounding it contains just the same area as the inner circle, or one-fourth the area of the 30-inch circle.

12-BORE GUN AT 20 YARDS.

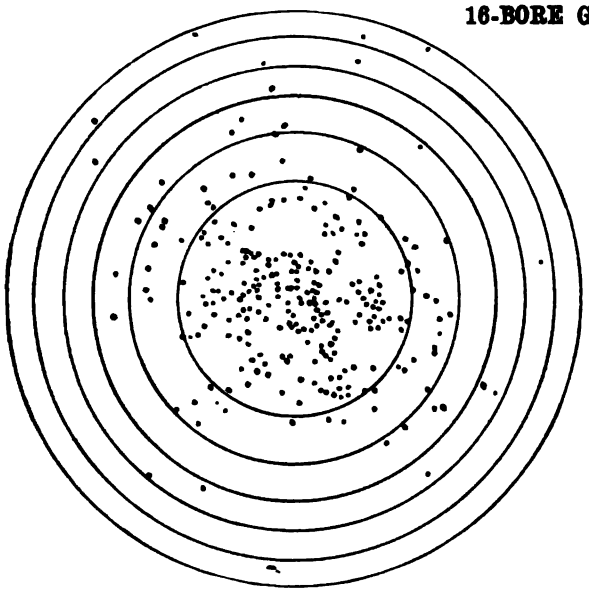


1.—First Barrel, with 1oz. shot.

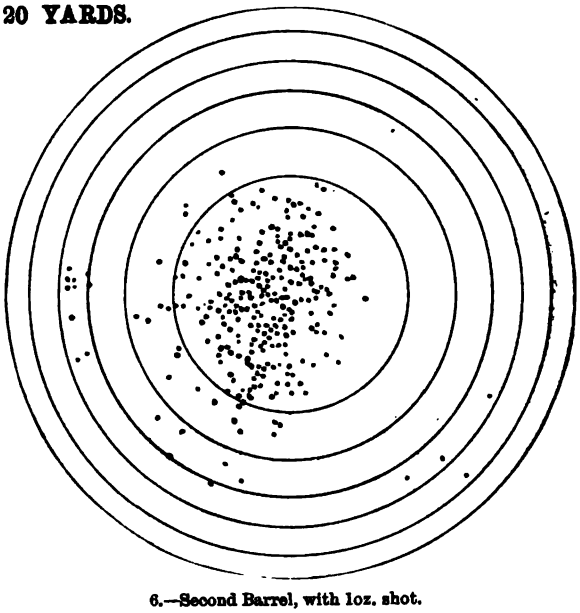


2.—Second Barrel, with 1oz. shot.

16-BORE GUN AT 20 YARDS.

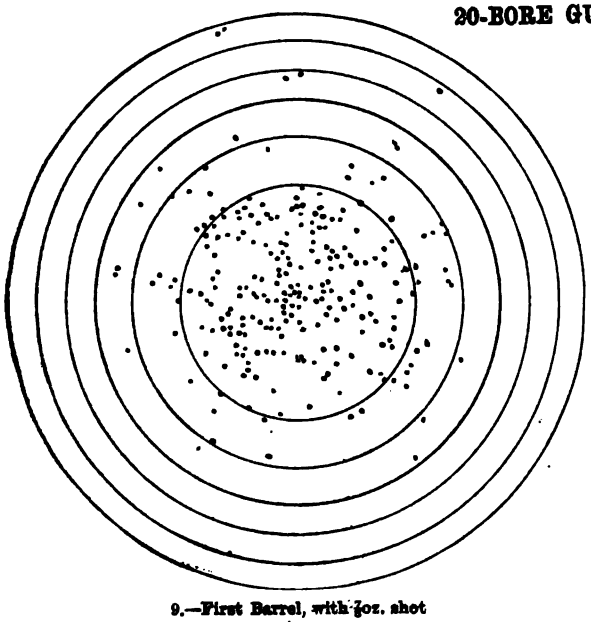


5.—First Barrel, with 1oz. shot.

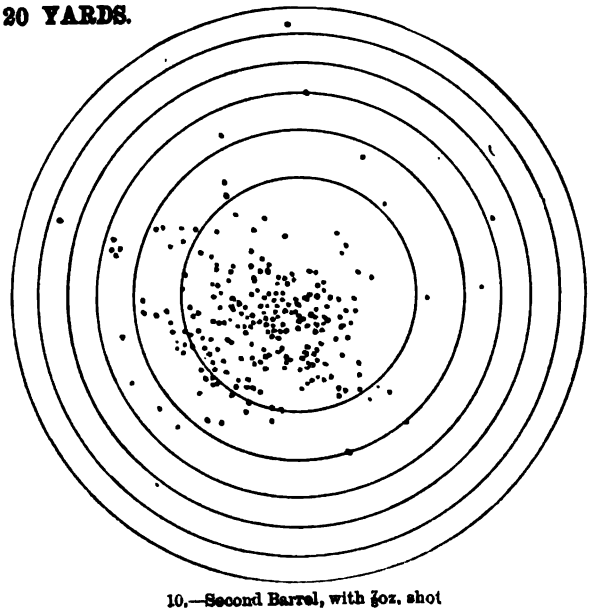


6.—Second Barrel, with 1oz. shot.

20-BORE GUN AT 20 YARDS.

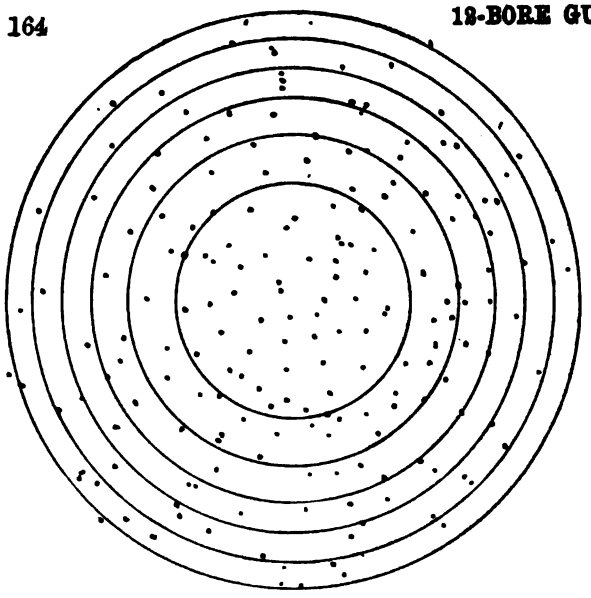


9.—First Barrel, with ¾oz. shot

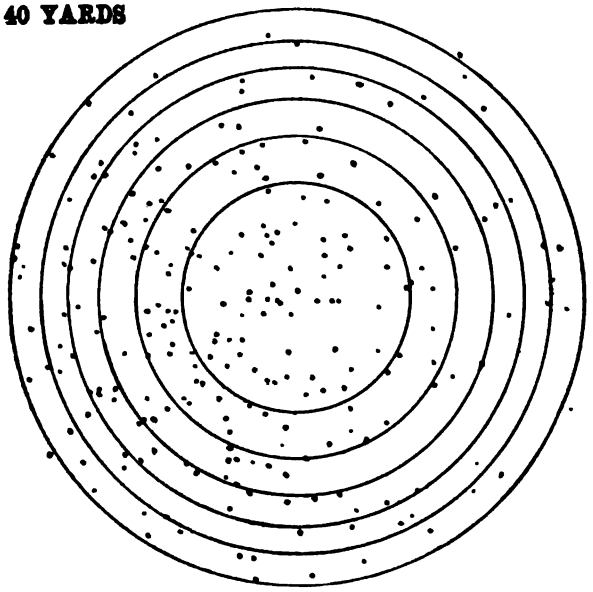


10.—Second Barrel, with ¾oz. shot

12-BORE GUN AT 40 YARDS

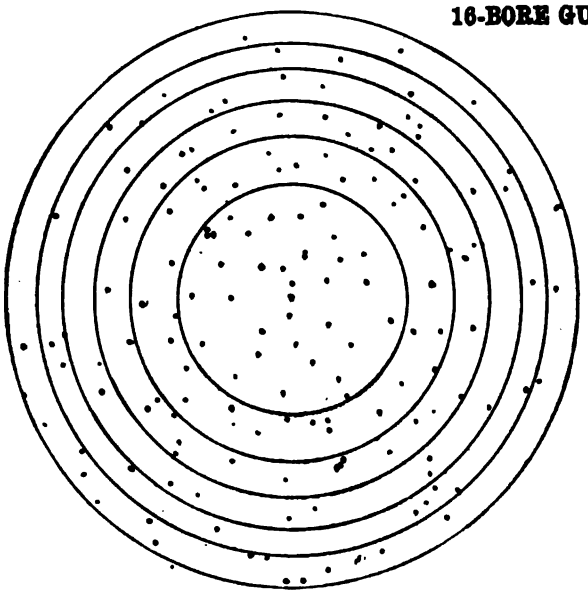


3.—First Barrel, with 1oz. shot.

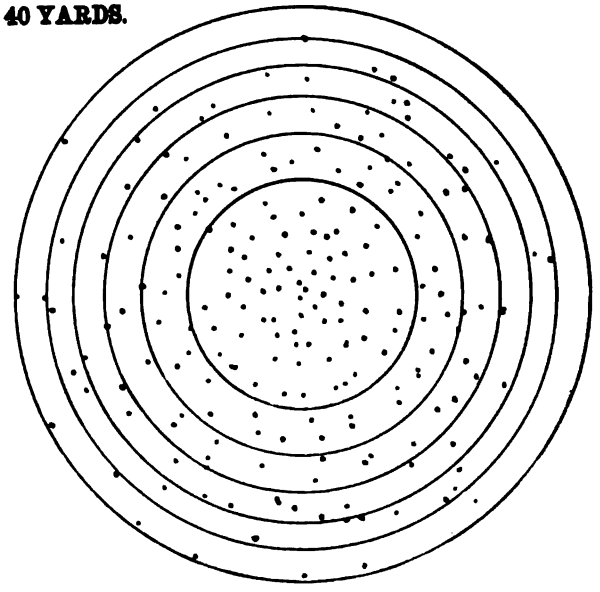


4.—Second Barrel, with 1oz. shot.

16-BORE GUN AT 40 YARDS.

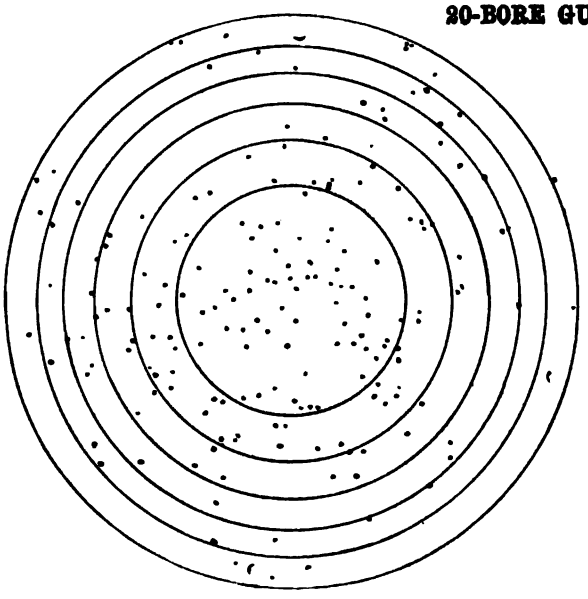


7.—First Barrel, with 1oz. shot.

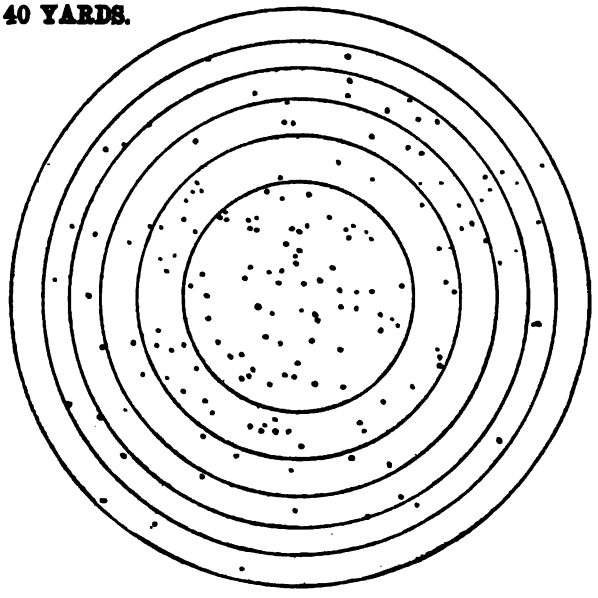


8.—Second Barrel, with 1oz. shot.

20-BORE GUN AT 40 YARDS.



11.—First Barrel, with ¾oz. shot.



12.—Second Barrel, with ¾oz. shot.

TRIAL OF VARIOUS GUNS OF SMALLER BORE.

24, 28, AND 32 GAUGES.

("*Field*," *June* 13, 1896; *Vol.* 87, *p.* 903.)

BESIDES the 12, 16, and 20-bore guns, of which we have already published records, we received for trial several guns of smaller gauge, viz., 24, 28, and 32-bore. Of the 28-bore we now give particulars. The charge used was 25grs. of powder, and ¾oz. of No. 6 shot. As compared with a 12-bore, using 1⅛oz. of shot, the pattern (64) given by the cylinder barrel is about equal to a pattern of 120 with the larger gun; and the pattern with the choked barrel (98) is about equal to 180 with the 12-bore, in the 30in. circle at 40 yards. For comparison with the records of the larger bores, we state the patterns and killing circles as follows:

	RIGHT BARREL.			LEFT BARREL.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
Pattern	149	98	64	154	120	98
Circle	26in.	33in.	22in.	22in.	30in.	30in.

We are unable to give particulars either of the recoil or the stress in the barrel. For guns of smaller bores than 20 we have no crusher-gauges; and every bore requires the gauge to be made exactly to its own dimensions. The recoil was not taken, because the "hands" of the stocks of these guns are small, and might possibly get broken if compelled to move the comparatively heavy mechanism of the recoil machine, which was only designed for use with guns of greater weight.

28-BORE GUN, No. 544; weight, 4lb. 15oz.; barrels, 28in.

Barometer, 29·30. Thermometer—Dry, 69°; wet, 63°.

FIRST BARREL.—Powder, 2½grs.; ¾oz. No. 6 shot (168 pellets).

	40 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	12	11	6	6	9	6	35	133	1167	
2	17	23	13	19	7	5	72	96	1172	
3	21	17	17	14	11	9	69	99	1173	
4	23	19	14	16	10	10	72	96	1220	
5	20	23	19	14	8	8	76	92	1230	Not
6	9	6	8	8	10	11	31	137	1163	taken.
7	18	24	16	14	4	11	73	96	1172	
8	25	16	17	10	7	6	68	100	1176	
9	20	23	15	12	9	7	70	98	1181	
10	22	21	18	16	12	10	77	91	1167	
Aver.	19	18	14	13	9	9	64	104	1182	

	30 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	38	29	25	12	17	11	104	64		
2	22	22	22	17	22	13	83	85		
3	37	24	23	18	16	15	103	66		
4	31	19	19	16	13	8	85	83		
5	38	28	26	14	15	11	106	63		
6	35	30	16	18	12	14	99	69		(As above.)
7	31	25	23	15	10	12	94	74		
8	40	29	20	19	15	10	108	60		
9	34	27	24	16	13	9	101	67		
10	28	25	23	20	19	15	95	73		
Aver.	33	26	22	17	15	12	98	70		

	20 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	88	45	18	6	5	3	157	11		
2	90	32	21	8	1	4	151	17		
3	82	39	20	11	6	7	152	16		
4	19	41	36	30	8	10	126	42		
5	93	30	17	9	5	4	149	19		(As above.)
6	50	46	31	18	9	7	145	23		
7	86	49	16	7	3	3	158	10		
8	78	48	22	12	7	2	155	13		
9	91	33	19	10	5	5	153	15		
10	80	41	15	12	4	6	148	20		
Aver.	76	40	21	12	5	5	149	19		

SECOND BARREL.—Powder, 25grs.; ¾oz. No. 6 shot (168 pellets).

	40 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	29	27	21	20	17	12	97	71		
2	40	31	18	13	8	7	102	66		
3	36	27	20	15	12	5	98	70		

	40 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
4	33	35	22	17	10	7	107	61		
5	31	29	23	13	7	9	96	72		
6	39	30	20	16	11	6	105	63		(As before.)
7	33	28	22	14	9	10	100	68		
8	33	33	19	13	6	15	98	70		
9	23	16	21	10	12	11	70	98		
10	38	29	23	15	10	8	105	63		
Aver.	34	28	21	15	10	9	98	70		

	30 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	24	15	18	12	7	9	69	99		
2	56	39	23	11	8	5	129	39		
3	42	27	33	21	8	7	123	45		
4	55	38	20	13	6	8	126	42		
5	48	36	27	16	8	7	127	41		
6	44	30	24	20	11	5	118	50		(As above.)
7	52	36	26	14	7	6	128	40		
8	46	40	23	16	10	9	125	43		
9	58	39	21	12	7	4	130	33		
10	50	37	25	14	9	6	126	42		
Aver.	48	34	24	15	8	7	120	48		

	20 YARDS PATTERN.							
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	126	32	9	1	0	0	168	0		
2	121	27	7	5	2	3	160	8		
3	57	36	23	14	14	4	133	35		
4	128	21	10	4	1	2	163	5		
5	43	34	30	10	14	11	117	51		
6	123	22	8	6	4	2	159	9		(As above.)
7	128	24	6	3	2	0	161	7		
8	66	35	28	16	8	5	145	23		
9	120	30	7	5	0	1	162	6		
10	125	28	8	3	2	1	164	4		
Aver.	104	29	14	7	5	3	154	14		

("*Field*," *June* 20, 1896; *Vol.* 87, *p.* 946.)

AMONG the small-bore guns recently sent to us for trial was a 32-bore—or, rather, a gun which is bored for the No. 32 brass "perfect" cases, but bears the 29-gauge proof mark. Some loaded cartridges were sent with this gun, and they contained 16grs. of powder and ¾oz. of No. 5 shot (163 pellets). This little gun weighs only 3lb. 1oz., and has 22in. barrels; and the shortness of barrels has considerable influence in limiting the velocity of the shot. We stated, a fortnight ago, that we had tried a 16-bore gun with 22in. barrels, and no charge of powder that we could get in a 2¾in. cartridge would bring up the velocity to the standard attained by all longer guns, of 1160 feet per second. With the little 32, it will be seen, the average velocity barely reached 1000 f.s., although with No. 5 shot the speed should be rather higher than with No. 6. Whereas, with the 28 gun (also bored for "perfect" cases, and consequently about No. 24 gauge) the longer barrels gave velocities averaging rather more than the standard of 1160 f.s, as will be seen by the records given on the next page. For reasons mentioned in the previous column, we could not take the pressure in the barrel or the amount of recoil with these small bores.

GUN bored for 32 perfect case; weight, 3lb. 1oz.; barrels, 22in.

Barometer, 29·30; Thermometer—Dry, 63°; Wet, 65°.

FIRST BARREL.—Powder, 16grs.; ¾oz. No. 5 shot (163 pellets); "Perfect" cases.

	40 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil.
1	36	29	25	13	9	10	103	60	993	
2	25	22	19	14	12	11	80	83	983	
3	34	28	24	15	10	7	101	62	1007	Not
4	37	30	22	9	10	4	98	65	990	taken.
5	33	32	23	10	8	8	98	65	1003	
6	39	27	22	12	10	11	100	63	1010	
Aver.	34	28	23	12	10	8	97	66	998	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	72	41	17	15	7	5	145	18		
2	65	38	16	13	11	4	133	31		
3	68	42	20	10	8	6	140	23		
4	60	40	18	12	9	7	130	33	(As before.)	
5	65	43	21	13	6	8	142	21		
6	81	42	15	11	9	2	149	14		
Aver...	68	41	18	12	8	5	139	23		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	103	30	12	0	2	0	145	18		
2	120	20	8	4	3	2	152	11		
3	117	24	11	6	1	1	153	5		
4	119	25	9	2	1	0	155	8	(As above.)	
5	118	27	13	5	2	1	157	6		
6	100	36	9	4	5	0	149	14		
Aver...	112	27	10	3	2	1	153	11		

SECOND BARREL.—Powder, 16grs.; ¾oz. No. 5 shot (163 pellets); "Perfect" cases.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	30	22	21	17	11	10	90	73		
2	36	28	23	15	12	8	102	61		
3	34	30	24	13	10	14	101	62		
4	38	31	24	11	9	11	104	59	(As above.)	
5	34	23	19	9	16	15	85	78		
6	28	33	17	14	11	10	93	71		
Aver...	33	28	21	13	11	11	95	68		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	82	22	14	11	8	7	129	34		
2	51	28	21	14	11	5	114	49		
3	68	41	20	7	10	7	136	27		
4	80	29	18	12	10	9	139	24	(As above.)	
5	64	32	17	14	8	6	127	36		
6	75	34	22	10	6	9	141	22		
Aver...	70	31	19	11	9	7	131	32		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	126	21	1	2	0	1	150	13		
2	118	31	6	1	1	0	156	7		
3	123	25	4	3	1	1	155	8		
4	121	30	7	1	0	0	159	4	(As above.)	
5	116	27	11	2	1	2	156	7		
6	120	32	4	2	1	0	158	5		
Aver...	121	28	5	2	1	1	156	7		

GUN, No. 1008; bored for 28-gauge "Perfect" cases; weight, 4lb. 5oz.; barrels, 24in.

Barometer, 29·60; Thermometer—Dry 78°, Wet 68°.

FIRST BARREL.—Powder, 25grs.; shot, ¾oz. (202 pellets) No. 6.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil.
1	30	32	21	16	14	13	99	103	1193	
2	27	20	19	8	8	7	74	128	1128	
3	29	24	20	19	10	9	92	110	1176	
4	33	25	23	20	15	10	101	101	1172	
5	25	27	17	21	12	12	90	112	1181	
6	31	25	20	17	17	8	93	109	1149	
7	34	29	23	23	16	13	107	95	1167	
8	18	17	8	13	11	14	56	146	1176	
9	26	24	23	18	12	9	91	111	1186	
10	35	31	21	20	15	12	107	95	1172	
Aver...	29	25	19	17	12	11	90	113	1170	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	71	40	25	20	15	16	156	48		
2	66	41	35	17	12	8	159	43		
3	69	46	28	18	18	4	161	41		
4	55	48	32	16	14	7	151	51		
5	63	42	30	22	9	9	157	45		
6	57	46	25	14	11	10	143	60	(As before.)	
7	68	43	29	20	8	6	160	42		
8	70	34	27	22	13	9	153	49		
9	65	45	36	17	10	5	163	39		
10	59	47	33	19	14	11	153	44		
Aver ..	64	43	30	19	12	7	156	46		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	118	39	16	12	8	4	185	17		
2	133	37	18	6	4	2	193	9		
3	123	40	11	8	6	2	182	20		
4	152	25	13	5	3	1	195	7		
5	121	45	16	7	3	3	180	13	(As above.)	
6	145	32	10	3	2	0	190	12		
7	139	43	15	1	2	1	196	4		
8	150	27	13	4	0	2	194	8		
9	158	28	9	3	2	0	198	4		
10	128	41	14	9	3	1	192	10		
Aver...	137	36	13	6	3	2	192	10		

SECOND BARREL.—Powder, 25grs.; shot, ¾oz. (202 pellets) No. 6.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	38	23	22	20	16	12	103	99		
2	43	30	20	25	10	7	118	84		
3	40	24	23	20	15	10	107	95		
4	28	20	23	28	18	9	98	104		
5	41	23	18	16	11	11	101	101	(As above.)	
6	37	21	24	23	15	8	105	97		
7	33	13	23	21	8	13	93	109		
8	40	27	20	22	13	9	109	93		
9	35	21	15	24	16	16	95	107		
10	45	33	21	16	14	10	115	87		
Aver...	38	24	21	21	14	10	104	98		

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	61	42	17	25	12	11	145	57		
2	90	45	26	13	6	5	174	23		
3	88	40	22	16	9	8	168	33		
4	76	48	25	21	11	6	170	32		
5	86	41	24	17	8	5	168	34		
6	66	37	23	20	13	10	151	51	(As above.)	
7	91	44	22	15	9	7	172	30		
8	78	39	25	18	11	9	180	42		
9	67	42	30	25	15	13	164	38		
10	82	44	27	18	10	6	171	31		
Aver...	78	42	25	19	10	8	164	38		

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	145	35	10	5	2	0	195	7		
2	140	43	7	6	5	0	196	6		
3	133	37	13	9	2	3	192	10		
4	117	54	23	3	3	1	197	5		
5	128	41	15	6	5	2	190	12		
6	122	47	14	10	2	1	193	9	(As above.)	
7	139	40	12	5	3	1	196	6		
8	117	42	21	9	6	2	189	13		
9	141	45	5	2	3	1	193	9		
10	150	28	16	4	1	0	198	4		
Aver...	133	41	14	6	3	1	194	8		

("*Field*," *June* 27, 1896; *Vol.* 87, *p.* 985).

THESE TRIALS have now been brought to a conclusion, and we wind up our records with the particulars of a 24-bore (so called). Three out of the four little guns last tried are bored for "perfect" cases, and consequently are somewhat larger than the nominal size. One of the 28-bores was of the actual gauge, using paper cases; the others were about three sizes larger than their nominal number.

GUN, No. 5046; bored for 24-gauge "Perfect" cases; weight, 5lb. 1oz. barrels, 24in.

Barometer, 29·80; Thermometer—Dry, 78°; Wet, 68°.

FIRST BARREL.—Powder, 28grs.; shot, ⅞oz. (236 pellets) No. 6.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	24	23	22	20	13	10	89	147	1141	
2	22	26	26	26	16	14	100	136	1064	
3	25	23	25	18	12	11	91	145	1154	
4	27	18	24	20	10	15	89	147	1056	
5	16	26	23	22	13	10	97	139	1053	Not
6	22	24	18	15	17	13	79	157	1111	taken.
7	29	27	25	24	15	11	105	131	1124	
8	24	28	22	25	18	15	99	137	1095	
9	26	25	24	21	14	12	96	140	1132	
10	22	20	17	14	16	14	73	163	1119	
Aver...	25	24	23	20	14	12	92	144	1108	

Round.	30 YARDS PATTERN. 1st ring	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	47	51	28	28	15	16	154	82		
2	73	53	26	20	16	10	172	64		
3	71	50	25	22	18	13	169	68		
4	69	48	30	26	19	15	173	63		
5	73	37	32	18	24	9	160	76		
6	63	44	27	21	14	11	160	76	(As above.)	
7	50	52	28	27	18	14	157	79		
8	46	39	25	23	20	23	133	103		
9	75	46	29	20	15	10	170	66		
10	55	55	31	25	22	18	166	70		
Aver...	63	47	28	23	18	14	161	75		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	133	61	18	7	5	1	219	17		
2	122	56	23	11	9	4	212	24		
3	116	53	30	16	6	2	215	21		
4	127	49	22	13	8	2	211	25		
5	131	60	20	9	3	1	220	16		
6	125	45	26	10	10	3	206	30	(As above.)	
7	118	53	34	13	5	2	218	18		
8	130	62	17	6	2	1	215	21		
9	88	44	29	19	14	14	180	56		
10	122	51	25	15	7	3	213	23		
Aver...	121	53	24	12	7	3	210	26		

SECOND BARREL.—Powder, 28grs.; shot, ⅞oz. (236 pellets) No. 6.

Round.	40 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	33	30	23	16	11	8	102	134		
2	40	29	21	14	17	17	104	132		
3	36	30	24	17	15	13	107	129		
4	32	26	21	20	13	10	99	137		
5	32	32	30	18	16	6	112	124		
6	34	27	24	21	18	13	106	130	(As above.)	
7	38	33	26	16	14	9	113	123		
8	34	24	19	20	11	11	97	139		
9	30	25	13	27	13	14	95	141		
10	41	28	22	15	15	12	106	130		
Aver...	35	28	22	18	14	11	103	133		

Round.	30 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	43	28	32	25	13	15	122	114		
2	70	45	21	22	17	11	169	67		
3	46	55	29	26	15	12	156	80		
4	65	48	33	24	10	7	170	66		
5	69	36	35	22	14	8	162	74		
6	73	43	30	21	16	10	167	69	As before.)	
7	63	50	32	20	13	12	165	71		
8	73	41	35	15	20	9	163	73		
9	63	44	31	21	12	10	164	72		
10	76	47	23	19	15	13	170	66		
Aver...	64	43	32	23	14	11	161	75		

Round.	20 YARDS PATTERN. 1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	110	55	33	20	10	5	218	18		
2	101	64	35	16	6	6	216	20		
3	106	57	22	14	12	8	199	37		
4	99	59	30	19	8	3	207	29		
5	103	61	31	15	12	5	210	26		
6	111	63	26	17	14	6	217	19	(As above.)	
7	97	55	23	21	11	4	201	35		
8	105	60	32	15	6	3	212	24		
9	108	51	19	16	15	9	194	42		
10	103	63	29	18	13	5	213	23		
Aver...	104	59	29	17	11	6	209	27		

SUMMARY OF THE SMALL-BORES.

In the following summary of patterns and killing circles, those guns which were bored for the brass "perfect" cases are indicated by an asterisk (*). We also state the charges of shot used.

	First Barrel. 20yds.	30yds.	40yds.	Second Barrel. 20yds.	30yds.	40yds.
*24-bore (⅞oz. No. 6):						
Pattern	210	161	92	209	161	103
Circle	26in.	33in.	30in.	30in.	30in.	30in.
28-bore (paper; ¾oz. No. 6):						
Pattern	149	98	64	154	120	98
Circle	26in.	33in.	22in.	22in.	30in.	30in.
*28-bore (¾oz. No. 6):						
Pattern	192	156	90	194	164	104
Circle	22in.	30in.	30in.	22in.	30in.	30in.
*32-bore (¾oz. No. 5):						
Pattern	152	139	97	156	131	95
Circle	22in.	26in.	26in.	22in.	26in.	26in.

PROPORTIONS OF POWDER AND SHOT WITH VELOCITIES.

For purposes of general comparison, we give a summary showing how the proportions of powder and shot have varied in the respective bores when the charges have been regulated to produce the standard velocity; and also what differences have occurred with guns of less than 20-gauge, where the powder-charges have not been regulated in the same manner as with the larger bores.

	Powder and Shot.	Proportions.	Velocity.
Average of six 12-bores	38grs. to 1oz.	= 1 to 11½	1162 f.s.
" six 16-bores	35 " "	= 1 to 12½	1165 "
" nine 20-bores	33 " "	= 1 to 13½	1169 "
Average of six 12-bores	36grs. to ⅞oz.	= 1 to 10½	1162 "
" six 16-bores	34 " "	= 1 to 11½	1164 "
" nine 20-bores	32 " "	= 1 to 12	1163 "
One 24-bore (perfect case)	28grs. to ⅞oz.	= 1 to 14	1108 "
One 28-bore (paper case)	25grs. to ¾oz.	= 1 to 11	1132 "
One " (perfect case)	25grs. to ⅞oz.	= 1 to 13	1170 "
One 32-bore (perfect case)	16grs. to ¾oz.	= 1 to 20½	998 "

On looking over the two series of averages, with 1oz. and ⅞oz. of shot, in the 12, 16, and 20-bore guns, it will be observed that the velocities are practically equal (as, in fact, they were intended to be); but, as the size of the bore diminished, the less was the quantity of powder requisite to impart the standard velocity to the shot-charge. Thus, with 1oz. of shot, 33grs. in the 20-bore, and 35grs. in the 16-bore, gave the same impetus as 38grs. in the 12-bore; for, with the diminution of gauge, the length of the shot-charge increases, and the greater amount of frictional resistance to the movement of the

shot causes a larger development of explosive force in the powder. The relative proportions of powder to shot (omitting very small fractions) are stated, as well as the respective charges.

Under ordinary conditions, with the older varieties of nitro powders (which are about one-half the specific weight of black powders), the proportion of powder to lead is near about 1 to 12. Thus, 41 grains of nitro powder are one-twelfth the weight of 1¾oz. or 492 grains of shot; and 36 or 37 grains of powder are proportionate to an ounce of shot. When the proportion of shot much exceeds 12 to 1, the velocity does not come up to the standard; as is especially shown in the case of the 32-bore, where the shot-charge was rather more than 20 times the weight of the powder, and the speed of the shot was consequently very low.

Proportional Weight of Gun to Shot.

Another matter which it is desirable to take into consideration is the proportion between the weight of the gun and the weight of the shot-charge to be used therein. Generally speaking the gun weighs between 90 and 100 times as much as the shot; but occasionally there are much wider differences. Thus, to take the last gun in the previous table, the little 32-bore weighed but 3lb. 1oz., or 49oz., while the shot weighed ⅜oz.; so that the proportion of gun to shot was only about 65 to 1. On the other hand, the 28-bore on page 41 weighed 79oz., while the shot-charge was but ⅝oz.; consequently the proportion of gun to shot was 125 to 1, or nearly double the proportion of the little 32-bore. Hence the 32 kicked the shoulder severely owing to excess of shot; while the 28-bore was comparatively lightly loaded.

An easily-remembered formula, for ordering a comfortable gun, is to allow 12oz. in weight of the weapon for every eighth of an ounce in weight of shot—or, in other words, 96 of gun to 1 of shot. With such a proportion, the shot charge for the little 32-bore above mentioned would be half an ounce. For three-quarters of an ounce, the gun would weigh 72oz., or 4½lb.; for seven-eighths of an ounce, it would weigh 5¼lb.; for the full ounce, 6lb.; for 1⅛oz. it would be 6¾lb.; and for 1¼oz., 7½lb. If you go much below this proportion, you may expect severe blows on the shoulder. One of the light 12-bores tested in the recent trials weighed but 78oz.; and with the full ounce of shot it kicked amazingly. When one of the rounds was being fired, it gave the shooter so severe a blow on the face that it knocked out one of his teeth. But it was an excellent little gun when not overloaded; and with ⅞oz. was much pleasanter to handle than with 1oz. One reason why some of the 12-bores did not show better in these trials we believe to be due to their having been made needlessly light for guns of so large a gauge. The lightest of the 16-bores weighed 5lb. 5⅜oz., and the lowest 20-bore was 5lb. 4½oz.; whereas there were three 12-bores under those weights, the lightest being 4lb. 14oz.; while the heaviest of the 12's did not weigh so much as the heaviest of either the 16's or the 20's. A 12-bore is handicapped very severely when it gives half a pound to a pound in weight, and four or six inches in length of barrels, to a 20-bore which is competing on otherwise equal terms.

INFLUENCE OF VARIATIONS IN IGNITION.

("*Field*," *April* 11, 1896; *Vol.* 87, *p.* 539.)

Among the many interesting facts demonstrated in the course of the 12, 16, and 20-bore trials were the variations which occurred in the amount of velocity and recoil shown by cartridges which, as far as could be known, were exactly alike in their loading. These variations seem to have been due to differences in the ignition, as the charges of powder were all accurately weighed, the shot pellets were counted, the wads and the turnover were alike throughout, and there were no indications of any dissimilarity except as regards the surmised inequality in strength of the caps. On comparing the highest record with the lowest record among the rounds fired from the same gun, under similar conditions, one may ascertain what percentage of increase there is in the former, as compared with the latter, as regards both velocity and recoil.

We also append, under the percentage of recoil actually recorded, the theoretical *proportion* of increase in recoil, as calculated from the percentage of increased velocity; and it will be observed that, although the theoretical and actual results are in very close proximity with some guns, there are remarkable differences with others; and, if concordant results occur with one charge of shot, they not unfrequently vary with another charge. See, for instance, the records of the two 12-bores with 24-inch barrels in the following tables.

First we will give the records obtained with the ⅞oz. charge of shot, as they show more regular results than the larger charge; and, except with the very light 12-bore, it will be seen that the actual amount of recoil registered approximates pretty closely, in many instances, with the theoretical proportion based on the difference of velocity.

12-Bores, with ⅞oz. Shot.

Weight. lb. oz.	Barrels. Inches.	Lowest Record. Veloc.	Recoil.	Highest Record. Veloc.	Recoil.	Increase. Veloc.	Recoil.
5 13½	28	1132	21·0	1172	22·7	3½ %	8 %
						proportionate,	7 %
5 12½	26	1124	22·0	1195	24·3	6¼ %	11 %
						proportionate,	13 %
5 4	24	1143	25·3	1181	27·5	3⅓ %	8⅔ %
						proportionate,	7 %
4 14	24	1141	25·7	1186	30·0	4 %	17 %
						proportionate,	8 %
16-Bores, with ⅞oz. Shot.							
5 15	28	1141	20·8	1181	23·0	3½ %	10½ %
						proportionate,	7½ %
5 8¼	27	1132	22·8	1186	24·2	5 %	6 %
						proportionate,	10 %
5 5½	28	1132	22·8	1186	25·0	5 %	9½ %
						proportionate,	10 %
20-Bores, with ⅞oz. Shot.							
5 5½	28	1132	22·1	1195	24·7	5⅓ %	11⅔ %
						proportionate,	11½ %
5 4¼	28	1141	22·1	1205	24·3	5⅔ %	7⅔ %
						proportionate,	11½ %

Why the two 24-inch 12-bores, with exactly the same charge, and giving nearly the same velocities, should be so close together in the amount of recoil in the low record, and comparatively wide apart in the high record, is not easy to account for. The same guns, moreover, differed still further with the larger charge of shot, as will be seen by reference to the next table.

12-Bores, with 1oz. Shot.

Weight. lb. oz.	Barrels. Inches.	Lowest Record. Veloc.	Recoil.	Highest Record. Veloc.	Recoil.	Increase. Veloc.	Recoil.
5 13½	28	1128	26·7	1172	27·9	4 %	4⅓ %
						proportionate,	8 %
5 12½	26	1136	27·0	1220	30·0	5⅓ %	11⅓ %
						proportionate,	11½ %
5 4	24	1132	29·8	1181	31·1	4⅓ %	4⅓ %
						proportionate,	9 %
4 14	24	1141	28·9	1176	35·0	3 %	21 %
						proportionate,	6 %
16-Bores, with 1oz. Shot.							
5 15	28	1145	24·7	1179	25·6	3 %	3⅔ %
						proportionate,	6 %
5 8¼	27	1136	27·0	1188	29·0	4⅓ %	8⅔ %
						proportionate,	9 %
5 5½	28	1128	27·7	1195	29·7	6 %	7 %
						proportionate,	12½ %
20-Bores, with 1oz. Shot.							
5 5½	28	1136	27·4	1235	33·7	8½ %	23 %
						proportionate,	18 %
5 4¼	28	1136	26·7	1210	33·0	6½ %	23½ %
						proportionate,	13½ %

The above constitute about the first half of the guns tried, and it was not thought necessary to proceed further.

It will be observed that the theoretical proportion of increase in recoil is about double the actual percentage of increase in velocity. For the information of those not already acquainted with the fact, we may mention that the energy of recoil varies in proportion with the "square" of the gun's velocity; and if the excess over 100 (say 3%) be represented thus, 1·03, and that number be squared, or multiplied by itself, the result will be 1·06 and a small fraction; but we have not included the fractions in the above tables where they amount to less than ¼.

P.——T.

SPORTING GUNS AND GUNPOWDERS:

COMPRISING

A SELECTION FROM REPORTS OF EXPERIMENTS,

AND OTHER ARTICLES

PUBLISHED IN THE "FIELD" NEWSPAPER,

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PUBLISHERS' NOTE.

THREE years have gone by since the first part of this work was issued. We regret the delay, and sincerely deplore the cause. Even before the publication of Part I. the health of the Editor, Mr Frederick Toms, began to give way, and, much against his will, he had, while engaged on Part II., to desist from the work in which he had taken so keen a delight. His hope—our hope—was that the illness would prove only temporary; but, alas, the task once put aside was destined never to be taken up again by the same master hand. At the dawn of the present year death came as a relief to the sufferings of one to whom, when in health, no day was too long if there was work to be done. Other hands have completed the part, and we now send it forth in the hope that it may prove of much service to those interested in the subject with which it deals.

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PART II.

SPORTING GUNS AND GUNPOWDERS.

LENGTH OF BARREL, AND ITS INFLUENCE ON THE SHOOTING OF GUNS.

(*Field*, August 3, 1889; Volume 74, page 164.)

THE "CYLINDER" BARREL.

ABOUT a century and a half ago a committee of the Royal Society reported upon a series of experiments which they had carried out with guns of various lengths, in order to ascertain in what part of the barrel the charge of gunpowder was principally consumed, and what amount was blown out unburnt. Three-quarters of a century prior to those experiments—and not many years after the same society received its charter of incorporation from King Charles the Second—a paper was read by one of its members, Sir Robert Moray, with reference to various experiments for improving the art of gunnery, among which, for the purpose of ascertaining what length of barrel would give the best results, the gun was to be made very long in the first instance, and then gradually reduced by cutting off two inches at a time until it was found that the range of the gun fell off in consequence. It is also recorded that, some half a century before the Royal Society came into existence, Count Maurice of Nassau, Prince of Orange, and one of the most distinguished generals of his time, also had recourse to the process of gradually reducing the barrel of the gun in order to ascertain what length would be most effective.

It will be understood, therefore, that we do not profess any great originality of idea when we state that we have instituted certain experiments for the purpose of demonstrating the effects produced in sporting guns by gradually reducing the length of the barrels; but perhaps some of our readers may not be unwilling to learn what are the relative effects produced by shortening the barrels when used with Schultze, E.C., and other nitro powders, as compared with the old-fashioned black and new-fashioned brown explosives.

Last autumn, after we had carried out a trial of some small-bores of 24 and 28 gauge, in comparison with an ordinary 12-bore, it was remarked by a correspondent that the trial was not conclusive, because the guns were of unequal length, the 12-bore being some inches longer than its little competitors. In our opinion, however, the defeat of the small-bores was due, not so much to the difference in length of barrels, as to the fact that the little guns were asked to perform too much work with too little means—the quantity of lead they had to propel being disproportionately large in comparison with the charge of powder employed in the propulsion.

The remark alluded to, however, led us to make arrangements to test the effect of difference in length of barrel on the action of various explosives; and we accordingly had a pair of single-barrel guns (choke-bore and cylinder) made for the purpose of cutting them shorter after each series of experiments had been carried out, and then trying them anew, with the same powder and all other accessories as before. Every time, after the barrels had been reduced in length, they were restored to their original form in other respects—the cylinder barrel being opened out at the muzzle to just the same extent as at first, and the choked barrel (after undergoing sufficient compression to somewhat constrict the bore) being re-choked with the same tool as had been used to form the original choke. The barrels were likewise turned on the outside, so as to reduce them to the same thickness of metal at the extremity that they had in the first instance—the object being to reproduce, as far as possible, all the conditions that originally appertained to the gun, except as regards the mere difference in length of tube.

It is very generally believed that, for the proper combustion of black powder, a longer barrel is requisite than is needed for nitro-compounds; and it is frequently asserted that, although 26in. barrels may answer with the chemical compounds, they are practically useless with the old black mixture, owing to a portion of the powder being blown out of the barrel unburnt. Indeed, to compensate for such loss of propulsive force in short barrels, it is considered advisable by some authorities to increase the powder-charge as the barrels are reduced in length; so that more powder would be used for a 28in. barrel than for one of 30in., and less in the 28in. barrel than for one of 26in.

[The accuracy of this conclusion has since been effectively proved by the trials of 12, 16, and 20-bores carried out in 1896, and reported on at page 125 *et seq.*]

In the experiments we are about to particularise we did not think it desirable to make any variation in the charge, because it would complicate the question and render it practically impossible to determine how much of any observed difference in the shooting of the gun might be due to the alteration in length of barrel, or how much may have resulted from the change in quantity of powder. We accordingly adopted, with each kind of powder, exactly the same charge for all lengths of barrel, using 42grs. of the nitro-compounds, and 3drs., or 82grs., with No. 4 black powder, but with the brown powder, and with black of smaller or larger grain than that above stated, we adopted the charges recommended by Messrs. Curtis and Harvey as imparting the same velocity to the shot as 3drs. of No. 4; viz., 76grs. of No. 2, 86grs. of No. 6, and 87grs. of brown.

The respective charges of powder were all used with 1⅛oz. of No. 6 chilled shot (270 pellets to the oz.), in Eley's best cases, loaded with 11¾ black-and-pink wad over the powder, then a ⅜in. best felt, a white card between felt and shot, and another white card over the shot. With the brown powder, however, owing to the large amount of space it occupied, it was found requisite to omit the card between felt and shot, in order to afford a sufficient amount of turnover in the case. The black powders used in this instance, were not all made by Messrs. Curtis and Harvey. It had been represented to us, with reference to previous experiments, that, by using the black powder of one firm exclusively, it looked as if there were no other manufacturers of similar powder in existence; so in the present instance we adopted the No. 4 of Messrs. Curtis and Harvey (which is usually chosen as the standard of comparison in trials against nitro-compounds); while for No. 2 grain we took that of Messrs. Hall, and for No. 6 that of Messrs. Pigou, Wilks, and Laurence—these being the three firms that had been represented in the *Field* gun trials carried out in 1878 (and reported on in p. 110 *et seq.* of this book).

The tables hereafter given of the results of the shooting with the cylinder gun will speak for themselves for the most part. When the barrel was 28in. long, and again when it had been reduced to 26in., the shooting was fairly regular with the whole of the powders; but when the gun had been cut down to 24in., and again at 22in., some very wild shooting occurred with most of the powders, though not with the whole of them—the wildness generally taking the form of a scattering of the pellets round the circumference of the 30in. circle, leaving a blank in the centre, so that, in half-a-dozen instances, not a single pellet, out of a charge containing 304, was placed on the 10in. square plate of the force-gauge, fixed in the middle of the 30in. circle; and consequently no record of force was made. In other instances the pellets in the centre were few in number, only 4, 6, 7, or 9 pellets striking the 10in. square, although its area of 100 sq. in. comprised about one-seventh of the entire space of the 30in. circle.

Generally speaking, when there were very few pellets thrown on the centre plate, the force recorded was feeble; but occasionally it was otherwise, when the pellets came in a cluster—as in the case of seven pellets with No. 6 black powder from the 24in. barrel (in a line printed in *italic* in the table on next page), the force then being much higher than was shown with the same powder at any time during the whole series of experiments.

For details such as these, recourse must be had to the following

RESULTS OF SHOOTING WITH CYLINDER GUN.

28in. BARREL.

Schultze Powder.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
148	38 + 19	=	2·00
130	30 + 15	=	2·00
166	44 + 22	=	2·00
160	67 + 38	=	1·76
142	59 + 30	=	1·97
149	Average		1·95

E.C. Powder (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
130	48 + 25	=	1·92
162	52 + 26	=	2·00
153	41 + 20	=	2·05
129	39 + 20	=	1·95
188	60 + 31	=	1·94
142	Average		1·97

J.B. Powder (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
148	56 + 28	=	2·00
128	35 + 18	=	1·94
150	87 + 47	=	1·85
101	25 + 13	=	1·92
131	37 + 20	=	1·85
132	Average		1·91

Brown Powder (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
129	34 + 18	=	1·89
132	35 + 19	=	1·84
122	37 + 21	=	1·76
143	44 + 24	=	1·83
136	40 + 21	=	1·90
132	Average		1·84

No. 2 Black (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
140	54 + 27	=	2·00
154	50 + 25	=	2·00
136	35 + 20	=	1·75
142	28 + 15	=	1·87
130	33 + 19	=	1·68
140	Average		1·86

No. 4 Black (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
136	36 + 20	=	1·80
122	43 + 25	=	1·72
134	38 + 18	=	2·11
123	36 + 19	=	1·89
120	40 + 23	=	1·82
127	Average		1·87

No. 6 Black (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
133	54 + 29	=	1·86
149	45 + 25	=	1·80
160	54 + 28	=	1·93
142	40 + 22	=	1·82
150	48 + 25	=	1·92
143	Average		1·87

26in. BARREL.

Schultze Powder.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
138	33 + 20	=	1·65
142	37 + 19	=	1·95
153	45 + 25	=	1·80
149	56 + 32	=	1·75
140	35 + 19	=	1·84
144	Average		1·80

E.C. Powder (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
150	50 + 29	=	1·72
107	32 + 17	=	1·88
147	40 + 21	=	1·90
148	31 + 17	=	1·82
130	35 + 19	=	1·84
136	Average		1·83

J.B. Powder (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
146	51 + 30	=	1·70
144	34 + 16	=	2·12
147	38 + 23	=	1·65
122	28 + 13	=	2·15
110	33 + 21	=	1·81
134	Average		1·89

Brown Powder (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
136	45 + 24	=	1·87
138	41 + 22	=	1·86
130	51 + 28	=	1·82
120	42 + 22	=	1·91
121	38 + 20	=	1·90
129	Average		1·87

No. 2 Black (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
130	38 + 21	=	1·81
112	34 + 19	=	1·79
135	33 + 17	=	1·94
140	46 + 25	=	1·84
128	40 + 22	=	1·82
129	Average		1·84

No. 4 Black (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
139	46 + 25	=	1·84
124	40 + 22	=	1·82
130	43 + 24	=	1·75
121	40 + 23	=	1·75
129	37 + 20	=	1·85
129	Average		1·80

No. 6 Black (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
166	71 + 42	=	1·69
159	36 + 23	=	1·57
165	53 + 33	=	1·76
141	53 + 30	=	1·73
138	50 + 28	=	1·79
154	Average		1·71

24in. BARREL.

Schultze Powder.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
145	38 + 21	=	1·81
122	28 + 13	=	2·15
107	23 + 15	=	1·87
138	36 + 18	=	2·00
140	42 + 22	=	1·91
130	Average		1·95

E.C. Powder (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
Very wild shot; no centre.			
Ditto	ditto.		
Ditto	ditto.		
146	47 + 27	=	1·74
154	49 + 28	=	1·75
150	Average of two shots		1·75

J.B. Powder (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
122	50 + 27	=	1·85
136	29 + 14	=	2·07
64	6 + 4	=	1·50
155	54 + 29	=	1·86
142	53 + 27	=	1·96
124	Average		1·85

Brown Powder (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
115	33 + 16	=	2·06
154	43 + 22	=	1·95
83	18 + 9	=	1·44
150	46 + 23	=	2·00
140	41 + 20	=	2·05
128	Average		1·90

No. 2 Black (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
133	39 + 18	=	2·17
143	44 + 23	=	1·91
146	41 + 23	=	1·78
143	54 + 28	=	1·93
130	39 + 20	=	1·95
139	Average		1·95

No. 4 Black (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
149	30 + 16	=	1·87
149	64 + 32	=	2·00
130	33 + 19	=	1·68
139	34 + 18	=	1·89
146	56 + 28	=	2·00
143	Average		1·89

No. 6 Black (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
62	15 + 7	=	2·14
116	30 + 16	=	1·87
153	55 + 23	=	1·96
150	45 + 25	=	1·80
149	47 + 23	=	2·04
126	Average		1·96

22in. BARREL.

Schultze Powder.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
135	58 + 29	=	2·00
125	34 + 18	=	1·89
145	53 + 30	=	1·93
131	33 + 18	=	1·83
133	44 + 22	=	2·00
134	Average		1·93

E.C. Powder (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
128	35 + 19	=	1·84
145	60 + 32	=	1·87
130	37 + 20	=	1·85
161	42 + 21	=	2·00
150	53 + 30	=	1·77
143	Average		1·87

J.B. Powder (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
Wild shot; no centre.			
144	30 + 17	=	1·76
151	77 + 42	=	1·83
Wild shot; no centre.			
126	55 + 27	=	2·04
140	Average of three shots		1·88

Brown Powder (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
146	58 + 31	=	1·87
150	58 + 30	=	1·93
146	99 + 48	=	2·06
150	33 + 17	=	1·94
135	38 + 20	=	1·90
145	Average		1·94

No. 2 Black (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
140	40 + 23	=	1·82
Wild shot; no centre.			
131	44 + 23	=	1·91
128	18 + 9	=	2·00
130	36 + 23	=	1·57
132	Average of four shots		1·83

No. 4 Black (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
140	48 + 26	=	1·85
131	28 + 14	=	2·00
133	47 + 26	=	1·81
141	49 + 25	=	1·96
129	35 + 18	=	1·94
135	Average		1·91

No. 6 Black (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
137	50 + 27	=	1·85
141	25 + 15	=	1·67
151	46 + 26	=	1·77
153	52 + 31	=	1·68
140	44 + 23	=	1·91
144	Average		1·78

SUMMARY OF RESULTS GIVEN ABOVE.

Patterns with Cylinder Barrel.

	28in.	26in.	24in.	22in.	Mean of the whole.
Schultze, 42grs.	149	144	130	134	= 139
E.C., 42grs.	142	136	150*	143	= 143
J.B., 42grs.	132	134	124	140*	= 133
Brown, 87grs.	132	129	123	145	= 134
No. 2 Bk., 76grs.	140	129	129	133*	= 133
No. 4 Bk., 82grs.	127	129	143	135	= 134
No. 6 Bk., 86grs.	148	154	126	144	= 143
General Averages	139	136	134	139	= 137

Force-Records with Cylinder Barrel.

	28in.	26in.	24in.	22in.	Mean of the whole.
Schultze, 42grs.	1·95	1·80	1·95	1·93	= 1·91
E.C., 42grs.	1·97	1·83	1·75*	1·67	= 1·85
J.B., 42grs.	1·91	1·89	1·85	1·88*	= 1·88
Brown, 87grs.	1·84	1·87	1·90	1·94	= 1·89
No. 2 Bk., 76grs.	1·86	1·84	1·95	1·88*	= 1·87
No. 4 Bk., 82grs.	1·87	1·80	1·89	1·91	= 1·87
No. 6 Bk., 86grs.	1·87	1·71	1·96	1·78	= 1·83
General Averages	1·90	1·82	1·89	1·88	= 1·87

* The averages marked with the asterisk (*) are based on fewer rounds, owing to the "wild shots" mentioned in the larger tables.

table, which gives the results of the individual rounds; but for some purposes of comparison the summaries of averages may be found useful. It will be seen, for example, that in the mean of the whole twenty shots fired with each powder, there was not a very wide difference between them; and the general averages of the whole seven powders, with the different lengths of barrel, varied still less. As regards force, it will be observed that, in the general averages, the force recorded was lower when the barrel was at 26in. than when either longer or shorter. This, however, must be taken to be the result of an unfavourable day rather than mere difference in length or boring of the barrel. A similar falling-off in the force-record likewise occurred with the choked barrel, tried on the same day, but rose again on a subsequent day, when the barrels had been shortened to 24in.

We have not included in these tables the results of the shooting with the barrel when 30in. in length; but there is every reason to suppose that it would be practically the same as when at 28in. In our impression of June 22, 1889, we gave a summary of the results of shooting with the 30in. barrels, and the shot then used being below the standard weight, we had intended to try the barrels again with shot of 270 pellets to the ounce, but the barrels were inadvertently cut down before the experiments were carried out. The patterns, however—the pellets (304 in number) having been counted—were much about the same as with the 28in. barrel given above, whereas the force was rather lower, as would be the natural result of the pellets being not so heavy as they should have been.

(*Field*, Aug. 10, 1889; Vol. 74, p. 204.)

THE CHOKE-BORE.

OUR experiments with the choked barrel were similar in method to those with the "cylinder," of which particulars are published in the previous article; but the results varied in some respects, as might be expected from the difference in the boring of the guns. As was the case with the cylinder, the choke-bore gave tolerably regular patterns with the whole of the seven powders when the length was 28in. and 26in. When, however, the choked barrel was cut down to 24in., there was, as with the cylinder, some wild shooting with most of the powders, as will be seen by the fact that, with all except Schultze and No. 4 black powder, patterns occurred in which only about one-half or one-third of the normal number of pellets were placed in the 30in. circle, while the pellets on the 10in. plate were sometimes as low as 5 or 6. On the barrel being reduced to 22in., there were a few still wilder shots, with no pellets whatever on the 10in. plate, and these occurred with powders that did not shoot so wildly with the cylinder barrel; while some powders which shot more wildly with the cylinder, did not do so with the choke-bore. On referring to the general averages (page 172), it will be observed that, as the choked barrel was shortened, there seemed to be a greater tendency to fall off in pattern than had been exhibited by the cylinder; but it was not shown to an equal extent by all the powders.

As regards the force, when the barrel was 26in. long, there was a lower force-record with most of the powders used in the choke-bore, in like manner as there had been with the cylinder; but, as explained in the last article, this was probably due to the weather, which was less favourable when the 26in. barrels were shot than it was when the trials of other lengths were made. Contrary to the general impression, there was not very much reduction of force when the barrels were at their shortest, as compared with their greatest length; and where the diminution was most marked, it was not where it is usually expected, but was more noticeable in the nitro-compounds than in the black powders.

It must be observed, however, that some of the averages were affected by occasional irregularity of shooting with the short barrels. For example, it will be found that the average force with E.C., J.B., and the brown powder stands much higher with the 24in. barrel than with any other length, and consequently there seems to be a considerable falling-off on the barrel being reduced to 22in.; but on examining the full details of the larger table it will be noticed that these high averages are consequences of a few exceptional shots, which gave extraordinarily high records of force. Thus, with E.C., in one of the rounds with the 24in. barrel, less than a fifth of the entire charge was placed on the target, and only 6 pellets were on the 10in. plate. Had these pellets been evenly distributed, the force-record would doubtless have been low; but the 6 pellets being in a cluster, they retained the high velocity which appertains to "balled" shot, and so there was the marvellously high record of 2·83 per pellet with this round, whereas its predecessor had been 1·87 and its successor was 1·93. A very similar shot occurred with J.B., where 5 pellets gave a record of 2·80; whereas in one of the rounds with No. 6 black powder, where there were 6 pellets on the 10in. plate, but not in a cluster, the record was only 1·67 per pellet.

So far as conclusions may be drawn from one barrel of each kind of boring, it does not appear that, with charges of loose shot, these reductions in length of the gun have any considerable effect in lessening the striking force of the pellets at the end of a 40 yards range. Nor do these experiments confirm the impression that the black powders suffer much more severely than the nitro-compounds. It is curious that, with the cylinder gun, the brown powder was the only one of the whole series that exhibited a regular increase of force with each successive reduction in length of barrel. With the choke-bore the brown powder did not show so much regularity as with the cylinder, but it still kept up its force very well; while No. 2 was the most regular of the lot as regards force with the choke-bore, though it had not been so regular as others with respect to pattern.

Looking at the whole series of experiments, it would certainly seem that there is good ground for the statements of those who assert that short barrels will kill game at as great distances as long barrels; nevertheless it would likewise appear, from the occasional patchy and irregular shooting exhibited, that the short barrels are likely to give a greater percentage of clean misses.

We do not know how far the wildness of shooting exhibited by the majority of the powders with 24in. and 22in. barrels may be characteristic of short barrels in general. We have heard of some similar instances occurring with other short guns when tried at the target, but so few owners of guns are in the habit of systematically trying them at a target, that little information on the subject is forthcoming. If a wild shot altogether misses the game, the man who fired the shot knows not whether the miss was his own fault or that of the gun; and if a cluster of pellets chances to bring down the game at a marvellous distance (as some of the rounds here recorded might have done) the owner is likely to form the opinion that such shot is an ordinary characteristic of the hard-shooting qualities of his favourite weapon, without considering whether it was merely a "fluke," perhaps arising from partial balling of the shot, and seldom likely to be repeated. P.—T.

TO THE EDITOR OF THE "FIELD."

SIR,—Sportsmen are again indebted to you for a series of very interesting experiments on the results of shortening barrels, and, as I have myself gone over the same ground, I am not the least surprised at the results you have published. Many of your readers will doubtless remember that I have for many years strongly advocated, as well as used, short barrels, my favourite length being 24in., on account of their great handiness and the marvellous rapidity, as compared with 30in. barrels, with which they can be got "on" a rapidly moving object; and this preference on my part was brought about by the absolute conviction conveyed to my mind, from the result of these experiments, that the 24in. barrels could be got to shoot just as close, as strong, and as regularly as the conventional 30in., and the gun could be made quite as strong, while it was ¾lb. lighter. But you will say this is not all in concord with the results published last week. True; still I am not one whit shaken in my confidence in 24in. barrels, and we need not go far to find the satisfactory reason why my results worked out so differently from yours. In the first place, we started with different objects in view—you, to prove the difference caused by the mere shortening of barrels; I, to ascertain if short barrels could not be got to shoot as well as the longer; hence you, as stated in the preamble of your report, placed the inside of the barrel in the same condition as to "opening" behind and "relief" forward, so that the variation in your trials consisted in the length of cylinder in the middle of the barrel; in my trials the barrels were shot as they stood after shortening, and then the boring regulated and "tickled" up until I got the shooting up to standard. One of the results soon obvious to me was that the length of "opening" and "relief" must, within certain limits, be proportionate to the length of cylinder, and whenever this rule was violated to any extent, the shooting was "nowhere!" So far as the relief was concerned, the management of this was easy enough, provided you felt your way cautiously, but when it came to the opening behind being too long, the case was very different, there being but two ways of dealing with it, viz., either to pass a half gauge or whole gauge "bit" through the cylinder part of the barrel, which was objectionable on account of reducing strength and the gun deviating from the proof mark; the other was simply troublesome, to re-tap the breech end an inch or an inch or so farther, cut off the end and re-fit the plug, as it must be remembered my experiments were many years prior to breechloaders.

To return to the results obtained by you, I have not the smallest doubt that, had you proceeded on the same lines as I did, you would have found the 24in. barrels in every respect equal to the 30in. So convinced am I of this, that 24in. has been my favourite length for about forty years, and I have repeatedly pitted my short barrels against the 30in. of many of our best makers, and though I have frequently found them equalled, it has been seldom indeed that they

RESULTS OF SHOOTING WITH THE CHOKE-BORE.

28in. BARREL.

SCHULTZE POWDER.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
231	118	50	2·36
223	116	53	2·19
228	113	50	2·26
220	67	34	1·97
233	111	51	2·18
227	Average		2·19

E.C. POWDER (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
241	125	57	2·19
250	99	49	2·02
227	125	57	2·19
238	109	55	1·98
222	70	35	2·00
234	Average		2·08

J.B. POWDER (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
239	97	49	1·98
232	83	46	1·91
206	77	39	1·97
237	112	50	2·24
211	81	40	2·02
225	Average		2·02

BROWN POWDER (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
207	79	36	2·19
208	91	44	2·07
197	46	23	2·00
203	66	34	1·94
195	52	25	2·08
202	Average		2·06

No. 2 BLACK (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
209	89	45	1·98
232	96	50	1·92
207	77	39	1·97
175	56	31	1·81
160	60	31	1·94
195	Average		1·95

No. 4 BLACK (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
184	62	33	1·88
210	76	37	2·05
230	96	42	2·05
182	64	32	2·00
230	56	29	1·93
207	Average		1·98

No. 6 BLACK (28in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
229	96	50	1·92
200	64	36	1·78
206	75	41	1·83
211	91	51	1·78
220	104	52	2·00
213	Average		1·86

26in. BARREL.

SCHULTZE POWDER.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
206	90	46	1·96
209	98	48	2·04
200	44	24	1·83
219	65	33	1·97
234	96	50	1·92
214	Average		1·94

E.C. POWDER (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
220	90	48	1·87
230	94	50	1·88
227	91	47	1·94
214	51	27	1·89
202	54	29	1·86
219	Average		1·89

J.B. POWDER (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
208	36	22	1·64
232	104	52	2·00
218	78	44	1·77
200	88	45	1·96
231	117	61	1·92
218	Average		1·86

BROWN POWDER (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
192	57	27	2·11
184	87	42	2·07
167	54	30	1·80
193	76	35	2·17
185	81	40	2·02
184	Average		2·03

No. 2 BLACK (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
205	90	45	2·00
195	75	37	2·03
200	90	46	1·96
185	78	40	1·95
200	80	42	1·90
197	Average		1·97

No. 4 BLACK (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
200	74	37	2·00
206	71	38	1·87
202	107	54	1·98
195	100	52	1·92
189	70	35	2·00
198	Average		1·96

No. 6 BLACK (26in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
205	70	36	1·94
211	75	38	1·97
217	80	42	1·90
208	81	40	2·02
201	72	37	1·95
208	Average		1·96

24in. BARREL.

SCHULTZE POWDER.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
230	73	36	2·03
257	110	55	2·00
180	64	32	2·00
204	68	33	2·06
233	119	57	2·09
215	Average		2·04

E.C. POWDER (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
218	96	50	1·92
215	103	50	2·06
205	75	40	1·87
58	17	6	2·83
198	54	28	1·93
179	Average		2·12

J.B. POWDER (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
213	117	57	2·05
90	14	5	2·80
225	97	51	1·90
224	112	55	2·04
205	65	35	1·86
191	Average		2·13

BROWN POWDER (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
82	18	9	2·00
175	83	37	2·25
188	63	30	2·10
168	58	26	2·23
184	56	26	2·16
150	Average		2·15

No. 2 BLACK (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
217	107	51	2·10
208	89	48	1·85
154	56	27	2·08
198	60	32	1·87
61	17	9	1·89
168	Average		1·96

No. 4 BLACK (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
197	82	41	2·00
188	84	43	1·96
212	94	48	1·96
202	93	46	2·02
230	112	54	2·08
206	Average		2·00

No. 6 BLACK (24in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
190	75	43	1·75
176	47	28	1·68
150	28	16	1·75
82	10	6	1·67
200	120	64	1·87
160	Average		1·74

22in. BARREL.

SCHULTZE POWDER.

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
222	88	43	2·05
141	94	44	2·14
210	86	43	2·00
204	79	39	2·03
220	82	40	2·05
199	Average		2·05

E.C. POWDER (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
207	86	42	2·05
210	96	49	1·96
218	78	36	2·08
178	63	34	1·94
204	78	38	2·05
202	Average		2·01

J.B. POWDER (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
216	57	29	1·97
202	82	41	2·00
200	59	36	1·64
210	69	37	1·87
189	61	30	2·03
203	Average		1·90

BROWN POWDER (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
194	71	36	1·97
150	55	25	2·20
210	96	48	2·00
192	91	44	2·07
200	79	39	2·03
189	Average		2·05

No. 2 BLACK (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
178	57	31	1·84
172	68	34	2·00
207	82	41	2·00
206	84	45	1·87
198	82	40	1·98
192	Average		1·95

No. 4 BLACK (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
211	102	51	2·00
	Wild shot; no centre.		
199	94	46	2·04
190	85	34	2·50
200	46	23	2·00
200	Average of four shots		2·13

No. 6 BLACK (22in. barrel).

Pattern.	Force on Gauge.	Pellets on Plate.	Force per Pellet.
	Wild shot; no centre.		
174	45	24	1·87
190	64	32	2·00
183	67	36	1·86
112	48	26	1·85
165	Average of four shots		1·89

SUMMARY OF RESULTS GIVEN ABOVE.

PATTERNS WITH THE CHOKED BARREL.

	28in.	26in.	24in.	22in.	Mean of the whole.
Schultze, 42grs.	227	214	215	199	214
E.C., 42grs.	234	219	179	202	208
J.B., 42grs.	225	218	191	208	209
Brown, 87grs.	202	184	159	189	184
No. 2 Bk., 76grs.	195	197	168	192	188
No. 4 Bk., 82grs.	207	198	206	200*	203
No. 6 Bk., 86grs.	213	208	160	165*	187
General Averages	215	205	188	193	199

FORCE-RECORDS WITH THE CHOKED BARREL.

	28in.	26in.	24in.	22in.	Mean of the whole.
Schultze, 42grs.	2·19	1·94	2·04	2·05	2·06
E.C., 42grs.	2·08	1·89	2·12	2·01	2·03
J.B., 42grs.	2·02	1·86	2·13	1·90	1·98
Brown, 87grs.	2·06	2·03	2·15	2·05	2·07
No. 2 Bk., 76grs.	1·95	1·97	1·96	1·95	1·96
No. 4 Bk., 82grs.	1·98	1·98	2·00	2·13*	2·02
No. 6 Bk., 86grs.	1·96	1·96	1·74	1·89*	1·86
General Averages	2·02	1·95	2·02	2·00	2·00

* The averages marked with the asterisk (*) are based on fewer rounds, owing to the "wild shots" mentioned in the larger tables.

have been beaten. The results of such an untoward event was generally my ordering a new gun or a new pair of barrels, which should shoot better than the gun beating me; and by these tactics I have generally managed to keep in my cabinet some as good guns as could be produced. Some years ago I was induced, sorely against my own judgment, to order a gun with 26in. barrels, and, singularly enough, they turned out so inferior to what I was accustomed to, that I do not think I carried the gun half a dozen times. When a gunmaker tells me that he cannot undertake to make short barrels, say not less than 24in., shoot as well as the 30in., I always look upon it as a confession of incapacity, as I know others can do it, and that I could do it myself in my own lathe room. I need hardly remark that the above applies wholly to what is known as the old cylinder boring; but in these days, when choking is so thoroughly understood, there is even less difficulty in getting short choked barrels that will give results almost as the shooting may require, and I have no doubt that an experienced maker would turn out a full-choked gun with only about 18in. barrels, which would be equal to stopping any English game up to at least 45yds. in a clean and satisfactory manner. I may state here that I now possess a 16-bore choke with 22in. barrels, re-bored for me by Mr. W. Ford, with which 1oz. of No. 6 hard shot puts on a pattern of 180, with a force of 2·20, at 40yds., the pattern being particularly even and regular. This is sufficient to show what short barrels can do when they come from skilled hands. Such shooting as this is, in my opinion, quite good enough for all field shooting in England; in fact, I prefer it to better, unless, indeed, for occasions when game is wild and particularly difficult to get near, then I prefer the closest pattern that can be got, using No. 4 shot.

ONE WHO HAS FIRED SOME 20,000 TRIAL SHOTS AT MARKS.

Brighton, Aug. 7, 1889.

[We are much obliged to our old correspondent for the interesting particulars he gives of his experiments in days long past; but alterations at the breech end of the barrel formed no portion of our allotted task. With us the programme was limited to a shortening of the tube, and restoring the muzzle to its original state—every condition remaining exactly the same, except the length of the barrel. Had we been previously acquainted with what "20,000 Shots" had done, we could hardly have applied his practice, however satisfactory in itself, to our more complicated experiments. The "tickling up" of the barrel at breech and muzzle until it gave the best results would be comparatively easy when trying only one kind of powder and one method of boring; but a gun that is regulated for one powder will not necessarily shoot equally well with a different explosive; and to carry out the "tickling-up" method with proper effect would have necessitated the application of the arrangement to fourteen barrels—that is to say a cylinder and choke-bore for each of the seven kinds of powder. Under such circumstances it would scarcely be possible to determine whether the differences exhibited in the shooting of the respective powders were due to the suitability or otherwise of the powder to a particular length of tube, or whether it might have arisen from the greater or less success that had attended the "tickling up" of the barrel after its reduction.

The firing of the whole of the powders from the same barrel may not show the highest development of pattern and penetration it is possible to obtain with each explosive; but the retention of constant conditions in every respect except length of tube affords, in our opinion, the fairest opportunity of tracing, step by step, the effects produced on each explosive by merely reducing the length of the gun; and the main purpose of our experiments was to ascertain whether there was a much greater loss of penetration with some powders than with others, when used with short barrels instead of long ones.—ED.]

(*Field*, Sept. 14, 1889; Vol. 74, p. 406.)

SHORTENED BARRELS WITH SPHERICAL BALL.

IN two previous articles (reprinted on pages 169 and 171) we published particulars relative to some trials of different kinds of powder with No. 6 shot, when the barrels were gradually shortened. The results went to show that, so far as could be judged from experiments with one cylinder gun and one choke-bore, there was not very much difference in the striking force of the pellets at the end of 40 yards, whether the barrel from which they were propelled was 30in. long, or only 22in.; but that the shortened barrels did not exhibit the same regularity of shooting as they had done when they were six or eight inches longer.

Charges of small shot, however, do not afford much conclusive evidence on the question whether there is any material loss of the propulsive force of the powder by reducing the length of the tube in which it is fired. When several hundred pellets are driven out of the barrel together, the force with which they strike an object at a distance is not dependent merely upon the speed with which they leave the muzzle of the gun, but is influenced by various conditions, one of them being the degree of compactness retained by the charge during its flight through the air. It does not invariably follow that an actual increase of propulsive force in the barrel will give greater penetration to a charge of small shot at the end of 40 yards; for, as has been found by experiment, an addition to the powder may, by causing the shot to scatter, lessen the ultimate striking force of the pellets, even though they would doubtless be driven out of the gun with a higher velocity. Such being the case, it was not easy to determine whether the small differences of result noticeable in the shooting of the various powders used in the experiments we recorded were really due to variations in the propelling power of the respective powders, or whether the differences might not have arisen from some other circumstances attendant on the firing of small shot.

With the purpose, if possible, of tracing out cause and effect more distinctly, we resolved to supplement the trials with No. 6 shot by others with spherical ball, fired from a smooth-bore gun under the same conditions as were adopted in the previous experiments, except as regards the substitution of the solid bullet for the ordinary shot-charge. This substitution being made, it becomes possible to ascertain, by means of the chronograph, what is the muzzle velocity of the projectile—which velocity, moreover, cannot be ascertained from a charge of loose shot. A knowledge of the speed at the muzzle having been acquired, the difficulties arising from abnormal retardation in a mass of pellets are thus eliminated; and, by comparing the records made with the various descriptions of powder, and the different lengths of barrel, one is enabled to trace more clearly the extent to which the respective explosives are affected by the shortening of the tube.

Everyone who has had practical experience in testing the various nitro-compounds will be aware how much more sensitive they are than black powder to what most people would consider very slight differences in loading; moreover, the nitro-compounds differ more or less from one another in the manipulation that is requisite to produce the best effect—some requiring a greater amount of pressure in loading, and more resistance to initial movement in the shot, by the use of tight-fitting wads, in order to develop an equal amount of propulsive force from the different explosives. But, although these facts are pretty generally understood, we question whether many people have any idea of the extent to which the idiosyncrasies of the powders exhibit themselves when a smooth-bore gun is used with spherical ball in place of the ordinary charge of small shot.

The cartridges we used were loaded as described in our account of the previous experiments—the charge of black powder being varied according to the scale recommended by Messrs. Curtis and Harvey as giving equal velocity with small shot. We added No. 1 powder to the sizes of grain previously tried, and the quantities used were—of No. 1, 72grs. or 2½drs.; of No. 2, 76grs. or 2¾drs.; of No. 4, 82grs. or 3drs.; of No. 6, 86grs. or 3¼drs.; and of brown powder, 87grs. Of Schultze, E.C., and J.B. powders, 42grs. of each were used. Instead of 1¼oz. or 493grs. of No. 6 shot, a spherical ball of 550grs. was substituted. The nitro powders were rammed to the same extent as before, viz., Schultze with light pressure, E.C. with more, and J.B. most of all. The same cases and wads were employed as with the shot experiments—viz., Eley's green cases, a black-and-pink 11½-gauge wad on the powder, next a 12-bore greased felt wad ⅜in. thick, then a thin card, and another card over the ball, with the case well turned over.

As previously stated, the muzzle velocity with the shot charges cannot be accurately ascertained; but it may be estimated as being somewhere about 1150ft. per second, a little more or less. When the bullets were fired from the 30in. barrel of the 12-gauge smooth-bore, the highest muzzle velocity was shown by the brown powder, which had the heaviest charge (87grs.); the speed attained being slightly over 1300 ft.sec. This considerable increase of the velocity of the bullet over that of the small shot, we attribute to the former not being retarded by the friction which acts as a clog on the movement of the latter, although, as will afterwards be seen, it likewise tends to develop the force of slow-burning powders. Next came the finest grain, No. 1, which had the smallest charge of black powder (72grs.); with this the velocity was rather under 1300 ft.sec. Then, with every increase in size of grain, there was a falling off in speed (despite the additional weight of powder), until No. 6 recorded about 1150 ft.sec. muzzle velocity. But much more remarkable diminutions occurred with the nitro-compounds; for Schultze and E.C. were both under 900 ft.sec., while J.B. showed only about 550 ft.sec. muzzle velocity.

It was obvious that these very low results with the nitro powders were due to the insufficient frictional resistance afforded by the bullet, which would be gradually pushed on by the gases of these slow-burning powders, before sufficient force was developed to impart

much impulse to the projectile; whereas the action of the quick-burning powders would be practically instantaneous. So far as weight alone was concerned, the bullet should have afforded more resistance than the shot, as the solid ball was nearly 60grs. heavier than the shot charge; but, as has previously been pointed out in our columns, the main resistance arising from loose shot is due to the mass of pellets being driven together by the force behind them, so that they are tightly compressed against the walls of the barrel; whereas with the spherical ball there is scarcely any friction in the smooth-bore, as only the periphery of the ball touches the interior of the tube. Last year, when some experiments were tried with the Swedish concave wads on which we reported in the *Field*, we found that greater force was developed in the chamber of the gun, owing to the increased resistance caused by the cupped end of the wad being expanded by the force of the powder; and it was likewise found that the effect produced upon the nitro-compounds was far greater than with black powder. Accordingly, in our present experiments, we tried some of these Swedish wads with the nitro powders and ball. The result was a decided increase in muzzle velocity; the J.B. powder going up nearly 300 ft.sec., and E.C. and Schultze in a lesser degree. We also tried some wads giving still greater resistance—*i.e.*, instead of using one 11¾ gauge wad with a thick greased felt, we dispensed with the felt and used four of the 11¾ wads—the intention being that they should serve a similar purpose to that of the gas-checks used with big guns, in developing the force of the slow-burning powders. With these four tight wads we tried the two coarsest of the black powders, as well as the nitro-compounds, and with all there was an increase of muzzle velocity; but, as was to be expected, it was much greater with nitro-compounds than with the black powders. When No. 4 black was tried with the four tight wads, instead of the greased felt, &c., the muzzle velocity increased but slightly; with the slower-burning No. 6 there was rather more increase; with E.C. and Schultze the increase rose to about 40 per cent.; and with J.B. it amounted to 100 per cent. But, notwithstanding this large increase, J.B. still gave lower velocity than either of the others; though, if the cartridge case had permitted the introduction of a larger number of tight wads, there would doubtless have been a further development of force with the increased amount of resistance. The respective muzzle velocities imparted to the bullets by the different powders with the various wads, when fired from the 30in. barrel, were as follows, the figures given representing the averages of several rounds—generally three; but if there seemed to be any irregularities, they were sometimes extended to six or more.

Powders.	Ordinary Wads.	Swedish Wad.	Four tight Wads.
J.B. (42grs.)	556 ft.sec.	846 ft.sec.	1110 ft.sec.
Schultze (42grs.)	868 ,,	999 ,,	1234 ,,
E.C. (42 grs.)	892 ,,	916 ,,	1229 ,,
No. 6 Black (86grs.)	1158 ,,	—	1173 ,,
No. 4 Black (82 grs.)	1185 ,,	—	1192 ,,
No. 2 Black (76 grs.)	1265 ,,	—	—
No. 1 Black (72 grs.)	1294 ,,	—	—
Brown (87grs.)	1303 ,,	—	—

It will be seen that we did not try the Swedish wads with any but the nitro-compounds; nor did we try the four tight wads with either of the powders which gave high velocities without them.

Having, so to speak, cleared the ground by these preliminary experiments, we proceeded to the main trial of the gradually shortened barrel, with the seven kinds of powder previously tried with the shot charge—omitting the No. 1, which had been temporarily introduced, as a matter of curiosity, to see how it would behave as compared with those of coarser grain. The barrel that was cut down was practically a cylinder throughout—the ball fitting the bore with sufficient tightness to hold rather firmly, but being pushed through the barrel with very slight pressure. As a consequence of the preliminary experiments, the three nitro-compounds were used with four tight wads, while the ordinary wads were employed with the black and brown powders. The barrel was shortened 2in. at a time, until it was reduced to 20in. in length; and, the velocities having been ascertained by chronograph, the speed of the bullet at the muzzle came out as follows, with the respective powders and length of barrel—these figures again being averages of three or more rounds:

Powders.	30in.	28in.	26in.	24in.	22in.	20in.
	Ft.-sec.	Ft.-sec.	Ft.-sec.	Ft.-sec.	Ft.-sec.	Ft.-sec.
Brown (87grs.)	1303	1270	1234	1214	1194	1161
No. 2 Bk. (76grs.)	1265	1224	1178	1151	1117	1093
No. 4 Bk. (82grs.)	1185	1158	1123	1099	1065	1040
No. 6 Bk. (86grs.)	1158	1143	1118	1076	1034	979
Schultze (42grs.).	1234	1198	1111	997	897	731
E.C. (42grs.)	1229	1204	1102	995	900	743
J.B. (42grs.)	1110	1086	970	813	687	445

We pointed out (page 171), when commenting on the performances of the short barrels with No. 6 shot, that, contrary to a commonly-received impression, the nitro-compounds showed indications of more loss of force, as the barrels were reduced, than was exhibited by the black powders. This is fully confirmed, now that the muzzle velocities of the bullets have been ascertained; and it seems to be only a necessary consequence of the difference in the rate of combustion and gas-producing qualities of the respective powders. It is often said that the nitro-compounds are quick in their combustion; but we have before shown that that is a mistake, so far as concerns the sporting powders which alone we have to take into consideration. Nitro-compounds are no more all alike in their method or rate of combustion than are black powders; and the results of the present experiments are confirmatory of the information previously published, and ascertained by a different method of experiment. The figures given in the last table show that, of the velocities imparted to the bullet by the respective powders, those arising from the black and brown explosives were mainly acquired in the first two-thirds of the 30in. barrel, but were added to in some slight degree in the remaining one-third; whereas with the nitro-compounds, owing to their slower combustion, and the larger amount of gas that comes into action in the latter part of the barrel, a very large proportion of the velocity is imparted in the last 10in. of the tube. This will be seen more clearly when the total velocity from the 30in. barrel is represented by 100, and the percentage is given of the amount attained in the first 20in., and of the increase made between 20in. and 30in.

	Velocity imparted in the first 20 inches.	Velocity added in the last 10 inches.
Brown powder	1161 f.s., or 89 per cent.	142 f.s., or 11 per cent.
No. 2 Black	1093 f.s., or 87 ,,	172 f.s., or 13 ,,
No. 4 Black	1040 f.s., or 86 ,,	141 f.s., or 14 ,,
No. 6 Black	979 f.s., or 85 ,,	179 f.s., or 15 ,,
E.C.	743 f.s., or 60 ,,	470 f.s., or 40 ,,
Schultze	731 f.s., or 59 ,,	503 f.s., or 41 ,,
J.B.	445 f.s., or 40 ,,	665 f.s., or 60 ,,

It will be readily understood, then, that if that portion of the barrel be cut off in which a slow-burning powder adds from 40 to 60 per cent. to the velocity, the deteriorating effect of the reduction must be very marked when compared with that occurring with a quick-burning powder which adds only from 10 or 15 per cent. in the same part of the barrel. Everybody knows that a small-grained black powder is quick in combustion, as compared with a coarse-grained powder of the same description, and is prepared for the differences between No. 2 and No. 6 grain; but many persons suppose that with the nitro powders there is merely a slow ignition, and a very rapid combustion afterwards. This, however, is not the case with the sporting nitro-compounds; but such a remark would seem really to apply to the brown powder above mentioned (which is not a nitro-compound). From the low pressure this brown powder exhibits in the chamber of the gun it apparently must ignite slowly, yet it also must evolve a very large volume of gas immediately afterwards, in order to impart the high velocity that the projectile attains within 20in. of the breech.

It must be borne in mind, however, that the above observations with respect to the action of the respective powders, when used with spherical ball, must not be construed as representing their effect on charges of small shot; for here the conditions are considerably altered. As previously stated, the resistance of a spherical ball in a smooth-bore is very trifling, whereas that of a charge of small shot is very considerable. It has been shown in the *Field*, on a former occasion, that the resistance of 1¼oz. of No. 6 shot was so great that it took 18lb. dead weight to push the charge through the greater part of a 12-bore barrel, and about 7lb. additional to force the charge through the choke; in other words, the frictional resistance amounted to from 250 to 350 times the weight of the shot-charge. Under such conditions it may easily be conceived that an amount of gas-pressure which would suffice to add a little to the velocity of a spherical ball would not suffice to overcome the friction of a charge of No. 6 shot, and that, consequently, the last few inches of a 30in. barrel, may, with some powders, actually retard a charge of loose shot, although it increases the speed of the solid ball. Such would appear to be the case with the brown powder, as shown by the results of the shooting with the cylinder gun previously given (page 170). When the barrel was 28in. long, the force-record at 40 yards was 1·84; when the barrel was cut down to 26in. the record rose to 1·87; when further shortened to 24in., the force again rose to 1·90; and when, finally, the barrel was reduced to 22in., the force went up to 1·94. A question to which this may afford a reply has just been received by us from an old subscriber. He wishes to know our opinion as to what kind of black powder he ought to use in the second barrel of his gun,

which is 24 inches in length. In answer thereto we would say that, judging by the results of the above-mentioned experiments, the powder to which we have just alluded seems specially adapted to meet the requirements of his short barrel, and we should therefore advise him to give the brown powder a trial; but it should not be forgotten that the charge of brown powder must be about 10 per cent. more than would be required of No. 2 black to obtain nearly the same result.

Finally, we may say that, in the manufacture of the nitro-compounds above mentioned, the makers seem to have worked to the generally-accepted standard of a 12-bore barrel, 30in. in length; and when guns of that gauge are made shorter than the standard, there is a risk of lowering the obtainable results. Nevertheless, such a conclusion must not be applied too widely; for, if the gauge of the gun be lessened, there is greater resistance to the movement of the shot, and, the combustion of the powder being quickened, a small-bore might not be affected to the same extent as a gun of wider gauge. One conclusion, however, at all events, may be derived from these experiments, and that is, that they demonstrate the undesirability of drawing general conclusions respecting all powders, all bores, and all lengths of barrel, because certain experimental results may once have been obtained from a single set of conditions. P.—T.

TRIAL OF LONG AND SHORT BARRELS.

(*Field*, Oct. 26, 1889; Vol. 74, p. 579.)

We now give the results of a trial of several guns with barrels of different lengths, together with chronographic records showing the mean velocity of the pellets for the 40 yards range, as well as the striking force recorded by Mr. Walsh's force-gauge. The guns used in the experiments varied in length from 30in. down to 22in., and also differed in bore. All of them except that of 30in. were lent to us by different correspondents, in consequence of the discussion which has recently been carried on in our columns. Some of their owners supplied us with cartridges ready loaded; others gave us full details as to the charges they used, and the manner of loading which they wished to be adopted. In all instances we give particulars on these points, as well as the nature of the boring of the barrels. In several cases we have been requested not to publish the names of the owners or makers of the guns, and we therefore abstain from doing so in any instance: and this is the more desirable seeing that the weather was wretchedly bad for the trial, and, as may naturally be expected, none of the guns showed such high records as they would have done under more favourable conditions. It would not be just, therefore, in publishing these records, to let it be inferred that they represent the ordinary shooting properties of guns turned out by the makers of any of the weapons; but, as all were tried under the same disadvantageous circumstances, a fair comparison can be made as to their relative performances. With respect to the 30in. barrels, we may say that we tried three 12-bore guns of that length, and, as the one hereafter mentioned gave the best results of the three, we do not think it necessary to enter into details respecting the other two. The particulars relative to the various guns, and the charges and methods of loading, are as follows:

30in. Barrels.—Weight of barrels, 8lb. 10oz.; bore of right barrel, ·707in. in diameter from the breech to 5in. from muzzle, then relieved to ·709in.; left barrel, ·705in. at breech and for next 20in., then gradually reduced, and choked to ·69in. at the muzzle. Eley's 12-bore paper cases, loaded with 42grs. Schultze and 1¼oz. No. 6 shot (270 pellets to oz.), with tight 11/4 *Field* wad over powder, then ⅛in. felt, followed by a thin card, and another card over the shot.

27in. Barrels.—Weight, 8lb. 0½oz.; bore of right barrel, ·667in. at breech, gradually reduced to ·664 at 24in. from breech, and ·656in. at muzzle; left barrel, ·671in. at breech, diminishing to ·666 at 24in. from breech, then recessed to ·668in., and reduced to ·659 at muzzle. Kynoch's brass "perfect" cases, No. 20 size, loaded with 38grs. E.C. and 1oz. No. 6 shot, then one card, followed by three chemically prepared wads of 15/2 gauge, and a 16-gauge card over shot.

26in. Barrels.—Weight, 8lb. 3oz.; bore of right barrel, ·737in. at breech, gradually diminishing to ·733 at 2in. from muzzle, and the choke is ·705in.; left barrel, ·740in. at breech, reduced to ·733 at 2in. from muzzle, and choked to ·697in. Eley's 12-bore paper cases, loaded with 42grs. Schultze and 1¼oz. No. 6 shot, with tight *Field* wad, then ⅛in. felt, thin card, and another card over shot.

25in. Barrels.—Weight, 8lb. 14½oz.; bore of right barrel, ·730in. at breech, ·726in. at 3in. from muzzle, and ·690in. at choke; left barrel, ·732in. at breech, ·727in. at 3in. from muzzle, and ·697in. at choke. Eley's 12-bore paper cases, loaded with 42grs. Schultze and 1¼oz. No. 5 shot (218 to oz.); with card, pink-edged wad, and ⅛in. felt, then a card, and another card over shot.

24in. Barrels.—Weight, 8lb. 3½oz.; bore of right barrel, ·718in. at breech, gradually diminishing to muzzle, where the diameter is ·715in.; left barrel, ·733in. at breech, reduced to ·726in. at 3in. from the muzzle, where it is choked to ·698in. Kynoch's "perfect" case, No. 14 size, loaded with 38grs. E.C. and 1oz. No. 6 shot, with tight *Field* wad, ⅛in. felt, and thin card, and another card over shot.

22in. Barrels.—Weight, 8lb. 4oz.; bore of right barrel, ·686in. at breech, gradually reduced for 18in., where the diameter is ·680in., then recessed to ·685in., and choked to ·671in. at muzzle; left barrel, ·685in. at breech, gradually reduced for 18in., where it is ·681in., then recessed to ·686in., and choked to ·672in. Kynoch's "perfect" cases, No. 16 size, loaded with 42grs. Schultze, and 1oz. No. 6 shot, with thin card over powder, then pink-edged wad, ⅛in. felt, and card, and another card over shot.

It will be observed that the charges vary as well as the bores, and that the 25in. gun had 1¼oz. of No. 5 shot, with the same charge of powder as others used with 1oz. of No. 6. The muzzle velocities must vary considerably with such differences in the proportion of powder and lead, and the mean velocities for 40 yards would, though in less degree, likewise be affected. Such is found to be the case in the chronographic records contained in the following table, which gives the average of five shots for pattern and force-gauge, and of three rounds with the chronograph:

30in. Barrels.		Pattern in 30in. circle.	Force Record.	Chronograph Velocity.
42grs. Schultze and 1¼oz. No. 6 ...	Right	128	1·96	795
" " " "	Left	172	2·05	799
27in. Barrels.				
35grs. E.C. and 1oz. No. 6.....	Right	105	1·63	735
" " "	Left	136	1·86	747
26in. Barrels.				
42grs. Schultze and 1¼oz. No. 6 ...	Right	191	1·96	775
" " " "	Left	196	1·91	778
25in. Barrels.				
42grs. Schultze and 1¼oz. No. 5 ...	Right	159	2·37	704
" " " "	Left	161	2·40	706
24in. Barrels.				
38grs. E.C. and 1oz. No. 6.....	Right	132	1·70	695
" " "	Left	142	1·76	708
22in. Barrels.				
42grs. Schultze and 1oz. No. 6 ...	Right	117	1·88	799
" " " " ...	Left	123	1·83	781

It will be observed that the 25in. barrels stand out very conspicuously as regards the "force record," although the chronographic velocity is low, as might be expected from 1¼oz. of shot being used with only 42grs. of powder; but this high force-record is due to the shot being of No. 5 size, while all the rest had No. 6. This, of course, diminishes pattern and increases the striking force. Not only does the extra weight of the larger pellet impart a heavier blow, supposing the velocity to be equal, but the No. 5 pellet has a ballistic advantage over No. 6 of about 5 per cent., owing to its losing less speed in its flight. If allowance be made for these differences, the record (supposing the gun to shoot both sizes of shot equally well) would stand as follows—the pattern being increased by about 24 per cent., and a corresponding reduction being made in the force-record.

25in. Barrels.	No. 5 Shot. Pattern.	Force.	No. 6 Shot. Pattern.	Force.
42grs. and 1¼oz. No. 6—Right	159 ...	2·37	197 ...	1·83
" " " Left	161 ...	2·40	200 ...	1·85

On looking at the chronographic velocities in the first table, it is not obvious at a glance why there should be so much difference in the velocities of the shot from the various guns; but in most cases it is due to the difference in the proportion of powder used, and this will be seen more clearly if the percentage of powder to lead be substituted for the actual charges. We also convert the force-records into striking velocities, by taking the figures derived from the machine-record, and multiplying them by the number of pellets in the ounce of shot. Such being done, the results stand as follows:

Proportion of Powder.	Length and Gauge of Barrels.	Mean Velocities. Right.	Left.	Striking Velocities. Right.	Left.
19·2 % ...	22in., 14-bore.....	799 ...	781	494 ...	502
17·4 % ...	24in., 12-bore.....	695 ...	708	459 ...	475
17·0 % ...	30in., 12-bore.....	795 ...	799	529 ...	553
17·0 % ...	26in., 12-bore.....	775 ...	778	529 ...	516
16·0 % ...	27in., 16-bore.....	735 ...	747	454 ...	502
15·3 % ...	25in., with No. 5 shot	704 ..	706	517 ...	523
Ditto, converted to No. 6 shot		— ...	—	403 ...	499

Besides the cartridges tried, we received some loaded with other sizes of shot, and different wads. These will be reported on in the next article. P.—T.

LARGE SHOT AND SHORT BARRELS.

(*Field*, Nov. 30, 1889; Vol. 74, p. 760.)

BELIEVERS in small-bores have frequently claimed, on behalf of their diminutive pets, that they shoot large shot especially well—far better than the ordinary No. 6. Those little guns usually have very short barrels; and, as we were trying experiments with guns of different lengths and various gauges, we thought we would ascertain how these guns would perform with different sizes of shot, especially as some of their owners had sent us cartridges loaded with other shot than that previously reported on. We have accordingly tried all the guns alluded to in our previous article (page 175) with No. 4, 5, and 6 shot. With one of them there were also sent some cartridges loaded with No. 5½ shot (240 pellets to the ounce) and Swedish wads, which the owner of the gun had occasionally been using. The average of the respective records are given below; but we will first recapitulate a few particulars about the guns, and include some which were not stated in the previous article.

30IN. BARRELS, 12 GAUGE.—This was one of three 12-bores in our possession which we tried at the target, and finding that its force records with No. 6 shot were better and more regular than those of two other guns of the same dimensions, we chose it to represent the 30in. class, although it did not give so high a pattern as those more fully choked. It was loaded with 42grs. of Schultze and 1¼oz. of shot, in Eley's paper cases, with *Field* loading (viz., 11½ black-and-pink wad, ⅛in. best felt and a thin white card between powder and shot, and another thin card over the shot). Weight of gun, 7lb. 2oz.

27IN. BARRELS, 16 GAUGE.—Made by W. P. Jones, of Birmingham, and lent to us by its owner, Mr. W. W. W., who has done a good deal of rough work with it in the last six years. Loaded (in Kynoch's No. 20 brass "perfect" cases) with 1oz. shot, and generally with 35grs. of E.C., but one lot of cartridges had 42grs.; the wads in some of the cartridges were Swedish, of 16 gauge, and in others were three chemically-prepared cloth wads of 15½ gauge. Weight of gun, 6lb. 1oz.

26IN. BARRELS, 12 GAUGE.—Made by W. B. Leeson, of Ashford, Kent, who lent it to us for the trial. Loaded with 42grs. Schultze and 1¼oz. shot, in Eley's paper cases, with *Field* loading. Weight of gun, 6lb. 7oz.

25IN. BARRELS, 12 GAUGE.—Made by W. W. Greener, of Birmingham, and lent by "20,000 Shots." Loaded, in the first instance, as suggested by the owner, with 42grs. Schultze and 1¼oz. No. 5 shot, but also tried with same charge of powder and 1¼oz. of three sizes of shot. Weight of gun, 5lb. 13oz. This gun (having a cross-eyed stock, for shooting from the right shoulder with the left eye) did not work satisfactorily in the machine rest, and accordingly was fired from the shoulder.

24IN. BARRELS, 12 GAUGE.—Lent to us by its owner. In the first instance, as stated in the previous report, it was loaded with 38grs. of E.C. and 1oz. No. 6 shot, in Kynoch's No. 14 "perfect" cases, with *Field* loading. Subsequently it was tried with 42grs. E.C. and 1oz. of No. 4, 5, and 6, but with all three sizes the shot scattered so badly that we could obtain no satisfactory record. We thereupon resolved to try whether black powder would do better in these short barrels, and accordingly tried it with 3drs. of No. 4. It then shot much better than before, as will be seen by the records below. We also tried 42grs. of E.C. with Swedish wads. The results were very similar to those given by black powder, except that the E.C. still gave occasional wild shots. Weight of gun, 6lb. 10½oz.

22IN. BARRELS, 14 GAUGE.—Made by F. T. Baker for 16-gauge paper cases, re-bored by W. Ford for "perfects," and lent to us by its owner, "20,000 Shots." Loaded with 42grs. Schultze and 1oz. shot, in Kynoch's No. 16 "perfect" cases, with thin card over powder, a pink-edged wad, ⅛in. felt, and thin card, and another card over the shot. Weight of gun, 5lb. 7oz. Like the other gun of the same owner, this has a cross-eyed stock, and was shot from the shoulder instead of the machine-rest.

With each increase in the size of the shot, there was necessarily a reduction in pattern, and at the same time an increase in the force per pellet. The following results are the average of five rounds with each charge:

	Pattern.			Force Record.		
30IN. 12-BORE:	No. 6.	No. 5.	No. 4.	No. 6.	No. 5.	No. 4.
Right Barrel	118	102	85	1·96	2·31	3·09
Left ,,	163	131	103	2·10	2·19	3·19
27IN. 16-BORE:						
Right Barrel	118	98	81	1·93	2·23	2·94
Left ,,	138	106	91	1·95	2·42	3·06
26IN. 12-BORE:						
Right Barrel	190	159	113	1·99	2·44	3·09
Left ,,	215	176	129	1·95	2·47	3·29
25IN. 12-BORE:						
Right Barrel	173	141	95	1·94	2·16	3·12
Left ,,	193	139	116	1·95	2·19	3·11
24IN. 12-BORE:						
Right Barrel	104	95	92	1·97	2·38	3·09
Left ,,	131	102	95	1·90	2·25	3·16
22IN. 14-BORE:						
Right Barrel	123	94	73	1·93	2·40	3·29
Left ,,	128	122	98	1·93	2·39	3·16

It should be borne in mind, with reference to differences of pattern, that the 22in., 24in., and 27in. guns had but 1oz. of shot, while the rest had 1⅛oz. The powder charge was 42grs. with most of the guns, but it was only 35grs. with the 27in. barrels. No records are given above of either Swedish wads or No. 5½ shot: they were only used with the 27in. gun, and we give them separately, as follows, repeating the No. 6 records with cloth wads for the sake of comparison:

	Pattern.		Force Record.	
27IN. 16-BORE:	No. 6.	No. 5½.	No. 6.	No. 5½.
35grs. and three cloth wads—Right	113	139	1·93	2·33
,, ,, ,, ,, Left	138	184	1·95	2·26
35grs. and Swedish wads ... Right	157	144	2·00	2·42
,, ,, ,, ... Left	210	177	2·17	2·55
42grs. and Swedish wads ... Right	—	145	—	2·44
,, ,, ,, ... Left	—	166	—	2·59

It is very curious that, with the cloth wads, the pattern of No. 5½ shot should have been so much larger than with No. 6, although there were 30 pellets less in the charge; and it is also very curious that the Swedish wad should have increased the pattern of No. 6 so considerably, but left that of No. 5½ practically unaltered. It will be observed, too, that when the powder was increased from 35grs. to 42grs., there was scarcely any alteration either in the pattern or the penetration.

The differences in pattern between Nos. 4, 5, and 6 shot are usually very distinctly marked. The pellets of No. 4 are, in round numbers, about one-fourth heavier than those of No. 5, and the No. 5 one-fourth heavier than No. 6; and so No. 4 is about one-half heavier than No. 6: accordingly, if a gun shoots all three sizes with equal regularity, the No. 5 pattern will be about one-fifth less numerous than No. 6, while No. 4 will be about one-third less than No. 6. Conversely, the striking force of the pellets is higher, No. 4 being about one-half more than No. 6, and No. 5 one-fourth more than No. 6, supposing the velocity to remain unaltered. It frequently happens, however, that, although persons are prepared to see the diminished pattern, they have not an equally ready perception of the proportionate augmentation of the force-record, and consequently think the increase is much larger than it is in reality. In order to show the relative increase more distinctly, we turn the force-records into striking velocities for the different sizes of shot used in the respective guns, and present them in the following table:

STRIKING VELOCITIES WITH DIFFERENT SIZES OF SHOT.

		No. 6.	No. 5½.	No. 5.	No. 4.
30IN. 12-BORE:					
42grs., 1⅛oz.	Right ...	529 f.s.	—	504 f.s.	538 f.s.
,, ,,	Left ...	567 ,,	—	477 ,,	555 ,,
27IN. 16-BORE:					
35grs., 1oz., cloth wads	Right ...	521 f.s.	559 f.s.	496 f.s.	512 f.s.
,, ,, ,,	Left ...	527 ,,	543 ,,	523 ,,	532 ,,
Ditto, Swedish wad	Right ...	540 ,,	581 ,,	—	—
,, ,, ,,	Left ...	596 ,,	612 ,,	—	—
42grs., Swedish wad	Right ...	—	596 ,,	—	—
,, ,, ,,	Left ...	—	622 ,,	—	—
26IN. 12-BORE:					
42grs., 1⅛oz.	Right ...	533 f.s.	—	532 f.s.	538 f.s.
,, ,,	Left ...	527 ,,	—	538 ,,	572 ,,
25IN. 12-BORE:					
42grs., 1⅛oz.	Right ...	524 f.s.	—	471 f.s.	543 f.s.
,, ,,	Left ...	527 ,,	—	477 ,,	541 ,,
42grs., 1⅛oz.	Right ...	—	—	517 ,,	—
,, ,,	Left ...	—	—	523 ,,	—
24IN. 12-BORE:					
3drs. No. 4 black, 1oz.	Right ...	532 f.s.	—	519 f.s.	538 f.s.
,, ,, ,, ,,	Left ...	513 ,,	—	491 ,,	550 ,,
42grs. E.C., 1oz., Swedish	Right ...	513 ,,	—	506 ,,	550 ,,
,, ,, ,, ,,	Left ...	538 ,,	—	508 ,,	545 ,,
22IN. 14-BORE:					
42grs., 1oz.	Right ...	521 f.s.	—	523 f.s.	572 f.s.
,, ,,	Left ...	535 ,,	—	521 ,,	550 ,,

From the above figures it will be seen that the guns which exhibited any material increase in velocity with the larger shot were but few. With No. 5 the performance was generally poor, several guns being decidedly lower than with No. 6; but with No. 4 there were three or four that showed some improvement. Of course the larger pellets would, when moving with the same speed, give a heavier blow than smaller ones; thus, with equal velocity, the No. 4 pellet would strike with about 25 per cent. more force than No. 5, and about 50 per cent.

more than No. 6. But, beyond this, there is a ballistic advantage in heavy pellets, which enables them to pass through the atmosphere with less loss of speed than light pellets; and consequently, if a gun were capable of shooting all sizes of shot equally well, the heaviest pellets should have the highest velocity at the end of the range. There were only two of the above guns which showed this superiority in any marked degree with No. 4 shot. The 22in. gun did so with both barrels, but much more with the right than with the left; the 26in. gun did so with the left barrel only; the 24in. gun improved with the left when using black powder, and with the right when using E.C. and the Swedish wad. The 25in. gun exhibited an improvement in a minor degree with both barrels. This gun, it will be seen, gave about 40 f.s. higher velocity when used with 1¼oz. of No. 5 shot than it did with 1⅛oz., thereby fully justifying the predilection of its owner ("20,000 Shots") for the heavier charge of lead, with only 42grs. of powder. The 27in. gun, which was tried with No. 5½ shot, showed much more than the normal increase when using pellets of that size; yet, when tried with Nos. 4 and 5, it did not do so well as with No. 6. Verily, the different performances of the same guns, under very slight changes of circumstance, seem almost inscrutable; but sufficient has been said to show the undesirability of assuming, because this or that charge does well in one gun, that another gun may use it with equal success; or even of supposing that the same size of shot will do equally well in both barrels of the same gun.

About twelve months ago, we tried a 28-bore and a 24-bore against a 12-bore, with No. 4 and No. 6 shot, and published the records in the *Field* of Nov. 10, 1888. We will now bring the results into juxtaposition with those given above, arranging the guns according to the percentage of powder to lead; and, as those of last year were tried only with the left barrel, we will take only the corresponding records of our recent trial, and show what was the proportionate increase or decrease of speed with No. 4 shot in each instance, as compared with No. 6:

Proportion of Powder.	Length, bore, and weight of gun.	Striking Velocity with No. 6.	Striking Velocity with No. 4.	Increase or decrease with No. 4.
19·2 %	22in., 14 gauge (5lb. 7oz.)	535 f.s.	550 f.s.	+ 3 %
19·2 %	24in., 12 gauge (6lb. 10½oz.), bk...	513 ,,	550 ,,	+ 5 %
19·2 %	Same, with E.C. and Swed. wad	538 ,,	545 ,,	+ 1 %
17·0 %	30in., 12 gauge (7lb)	553 ,,	596 ,,	+ 8 %
17·0 %	another 30in. 12 bore (7lb. 2oz.)...	567 ,,	555 ,,	— 2 %
17·0 %	26in., 12 gauge (6lb. 7oz.)	527 ,,	572 ,,	+ 9 %
17·0 %	25in., 12 gauge (5lb. 13oz.)	527 ,,	541 ,,	+ 3 %
16·0 %	27in., 16 gauge (6lb. 1oz.)	527 ,,	532 ,,	+ 1 %
13·4 %	27in., 28 gauge (4lb. 14oz.)	491 ,,	554 ,,	+ 11 %
10·1 %	22in., 24 gauge (4lb. 1oz.)	454 ,,	538 ,,	+ 19 %

Here it will be seen that the 24 and 28 bores showed a greater increase of velocity with the No. 4 shot than did any of the larger bores; and so far their performances bear out the claim of their admirers as to their shooting better with large shot. It will also be seen that these guns had the smallest percentage of powder. Whether the larger guns would show a corresponding increase with large shot, if the proportion of powder to lead were assimilated in the different guns, is a question which only experiment can determine. P.—T.

P.S.—Since the above experiments were carried out we have received from Mr. W. (the owner of the 27in. gun that was there tried) a new gun which he has just had made for him by W. P. Jones, of Birmingham. It is a 12-bore, with Whitworth steel barrels, 26in. long, and weighs 6lb. 14oz. Mr. W. writes: "I gave the order to Jones last spring, and have had it built to shoot a special load that I have a great fancy for. It is intended to give the same killing circle as 1⅛oz. of No. 6 shot, but with a striking force that No. 6 is not capable of giving. To obtain this result, I load with 1¼oz. of No. 5, which gives 290 pellets, and comes very near to the conventional 300 pellets load of No. 6. I had originally intended to have 2¾in. chambers; but at Mr. Jones's suggestion I did not have the long chambers until I had first tried the short, and I found to-day that 48grs. of E.C., a Swedish wad, 1¼oz. of No. 5, and a thin card, can be just got into the ordinary case. I shall have as powerful a gun as it is possible to get in a light and handy form. In fact, after seventeen years of the most diligent study, and thousands of trial shots, with all sorts of guns and charges, I feel confident there is no combination at present known that will beat it for an ordinary man at all-round work. The recoil is not unpleasant at all—in fact, would not be noticed at game." With the gun, we received some cartridges loaded with two sizes of shot—one lot containing 42grs. of E.C. and 1⅛oz. No. 6, and the other containing 48grs. of E.C. and 1¼oz. of No. 5; with both loads Swedish wads were used. The results of the trials gave the following averages:

Shot.	Pattern.	Force Record.		Striking Velocity.
No. 6—Right Barrel	171	2·06	=	556 f.s.
,, Left ,,	216	2·19	=	591 ,,
No. 5—Right Barrel	152	2·63	=	573 ,,
,, Left ,,	209	3·04	=	663 ,,

EXPERIMENTS WITH SHORTENED BARRELS AS TO VELOCITY AND RECOIL.

(*Field*, Aug. 29, 1891; Vol. 78, p. 330.)

Some reports of trials with shortened barrels were published in our columns about two years since.* The chief purpose of those experiments was to ascertain the effects produced on the shooting of shotguns by reducing their length, but retaining other conditions the same as in 30in. barrels. The results went to show that cutting off a few inches from the length of the tube did not very much affect the pattern and striking force of a loose charge of shot at 40 yards, provided that the boring at the muzzle is properly attended to. The striking force of the pellets, at a fair shooting distance, does not depend, in the same degree as a bullet does, upon the mere velocity with which the charge is projected from the muzzle of the gun; for the results are considerably modified by the good or bad form maintained by the group of pellets while passing through the air. So that an increase in quantity of powder, which may have the effect of driving the shot from the barrel at a higher rate of speed, may nevertheless, in so doing, cause such a disturbance of the charge that the pellets may, at the end of 40 yards, retain less velocity than they would have had with a smaller quantity of powder propelling the shot-charge in more compact form. Some loss of muzzle velocity undoubtedly resulted through cutting down the barrels, as was rendered apparent by experiments with bullets carried out at the same period; but all powders were not affected alike; and the difference of frictional resistance between ball and shot-charge is such as to prevent any general conclusions from one kind of projectile being satisfactorily applied to the other class.

There were, in fact, various features connected with the experiments of 1889 which seemed to render further investigations desirable, especially with respect to the nitro powders; and for the purpose of carrying out some of these investigations we thought it best to use a gun of more than ordinary length, and to ascertain, by chronograph, the velocity of the shot on leaving the muzzle, instead of measuring its force after it had traversed a distance of 40 yards. We accordingly commenced operations with a 34in. barrel, bored cylindrical throughout, so that it might be cut down from stage to stage without the shortening of the tube in any way affecting the conformation at the muzzle. The gun was tried with spherical ball, with several sizes of small shot, and with eight varieties of powder.

The results of the experiments with this 34in. smoothbore showed conspicuously—as had been indicated with less effect in previous trials—that increased length in the barrel favours certain powders much more than it does others; that, with some of them, it adds considerably to the muzzle velocity of the ball, although it may not do the same with shot charges, which are influenced in much greater degree by frictional resistance in the barrel.

We published particulars of some of these experiments in the *Field* of 1890, but may here briefly state that, not only were there differences in the amount of recoil produced by the different kinds of powder, but the recoil with the same powder did not maintain any fixed ratio corresponding (as all are theoretically supposed to do) with the weight and muzzle velocity of the projectile. The *actual* recoil appears to be always very greatly in excess of the theoretical amount; and the degree of excess varies with the nature of the projectile, the length of the barrel, and some other conditions. Thus, when spherical ball was fired from the 34in. barrel, the excess of the actual over the theoretical amount of recoil was nearly 60 per cent.; and on the barrel being shortened to 30in., but otherwise fired under like conditions, this excess rose to more than 80 per cent. When, however, a charge of No. 6 shot was substituted for the ball (other conditions remaining as before) such wide divergences did not occur. With this shot-charge the *actual* recoil rose to 100% in excess of theory, but it was nearly equal with both lengths of barrel. With the nitro-compounds, other complications came in; as in the majority of instances these explosives showed higher muzzle velocity with shot than with bullet—the spherical ball not affording, in a smooth-bore gun, sufficient resistance to develop the force of these

* Here reprinted at pages 169, 171, 173, and 176.

powders; whereas it was very effectively done by small shot, owing to the pellets producing greater friction in the tube.

In continuing the experiments, with further reductions in length of barrel, we thought it needless to extend the trials with spherical ball, as we had already done similar work in the experiments of 1889; and, on discontinuing the bullet trials, we likewise discontinued the shot-charges of same weight as the ball, and restricted the remainder of the experiments to the ordinary charge of 1⅛oz. No. 6 shot, with 3drs. of black and brown powder, or 42grs. of the nitro-compounds. The barrel was cut down 4in. at each step, until its length was reduced to 10in., when the experiments came to an end.

The following tables show the variations in muzzle velocity with the different lengths of barrels and the respective powders. The "theoretic recoil" represents the calculated amount that corresponds with the muzzle velocity and weight of the shot-charge; whereas the "actual recoil" shows the amount that was automatically recorded upon the gauge of the mechanical rest to which the gun was affixed at the time it was fired; and, as the excess of the actual over the theoretic amount of recoil is difficult to compare in its crude form, we have converted the differences into percentages, which enable the gradations to be more readily seen. The column headed "effective work" shows the proportion which the energy of the shot-charge, as deduced from its weight and velocity on leaving the muzzle, bears to the greater amount of work done by the powder, as indicated by the actual recoil of the gun. Thus, if the amount of recoil recorded in practice is double as much as the theoretical estimate, the effective work is stated at 50 per cent.; and so on with other proportions.

BLACK AND BROWN POWDERS.

Powder and Barrel.	Muzzle Velocity.	Theoretic Recoil.	Actual Recoil	Excess of the Actual Recoil.	Effective Work.	Atmospheric Conditions.
	Ft.sec.	Ft.lb.	Ft.lb.	Ft.lb. Per Cent.	Per Cent.	Barom. Inches. Thermom. Dry. Wet.
No. 2 Bk.:						
34in.	1147	16·4	33·2	16·8, or 102%	49½	29·80 ... 59° 52°
30 ,,	1122	15·7	33·2	17·5, or 111%	47½	29·97 ... 37° 37°
26 ,,	1115	15·5	30·7	15·2, or 98%	50½	29·58 ... 48° 46°
22 ,,	1075	14·4	31·4	17·0, or 118%	46	29·66 ... 70° 63°
18 ,,	965	11·6	29·1	17·5, or 150%	40	29·80 ... 52° 51°
14 ,,	898	10·1	25·5	15·4, or 153%	39½	29·90 ... 48° 47°
10 ,,	813	8·2	23·0	14·8, or 180%	35½	29·40 ... 49° 49°
No. 4 Bk.:						
34in.	1122	15·7	31·8	16·1, or 102%	49½	29·60 ... 59° 54°
30 ,,	1114	15·5	31·5	16·0, or 104%	49	29·97 ... 37° 37°
26 ,,	1069	14·8	29·6	14·8, or 100%	50	29·58 ... 48° 46°
22 ,,	1046	13·7	29·1	15·4, or 113%	47	29·66 ... 70° 63°
18 ,,	963	11·6	28·8	17·2, or 149%	40	29·80 ... 52° 51°
14 ,,	868	9·4	26·7	17·3, or 184%	35	29·90 ... 48° 47°
10 ,,	793	7·9	23·5	15·6, or 199%	33½	29·40 ... 49° 49°
No. 6 Bk.:						
34in.	1094	14·9	27·6	12·7, or 85%	54	29·70 ... 61° 52°
30 ,,	1051	13·8	27·0	13·2, or 96%	51	29·97 ... 36° 36°
26 ,,	935	10·9	25·0	14·1, or 129%	43½	29·58 ... 52° 49°
22 ,,	910	10·3	25·2	14·9, or 144%	41	29·46 ... 59° 58°
18 ,,	876	9·6	23·9	14·3, or 150%	40	29·82 ... 51° 51°
14 ,,	792	7·8	22·1	14·3, or 182%	35½	29·90 ... 48° 47°
10 ,,	710	6·3	18·4	12·1, or 192%	34	29·40 ... 49° 49°
Brown:						
34in.	1102	15·2	28·5	13·3, or 88%	53	29·50 ... 60° 53°
30 ,,	1022	13·0	27·1	14·1, or 108%	48	29·80 ... 48° 48°
26 ,,	1034	13·3	29·9	16·6, or 124%	44½	29·58 ... 55° 50°
22 ,,	929	10·8	25·8	15·0, or 139%	42	29·65 ... 69° 64°
18 ,,	811	8·2	22·3	14·1, or 172%	37	29·82 ... 51° 51°
14 ,,	747	7·0	20·3	13·3, or 191%	34½	29·94 ... 59° 58°
10 ,,	684	5·8	16·8	11·0, or 188%	34½	29·38 ... 52° 51°

Generally speaking, in stating results, we have avoided very small fractions, having given the recoil only to the first decimal, and indicated the percentages to the nearest whole number; but we have made an exception under the head of "effective work," and have there stated the results to the nearest ½ per cent., as otherwise some records would appear to be identical when they really were not so.

The gradations of velocity, &c., do not always proceed with regularity, and we have therefore appended records of barometer and thermometer at the time of the trials, so that anyone interested in such particulars may make comparison, and attempt to find reasons for the irregularities; but we confess our inability to see that the atmospheric changes suffice to account for the differences in the records.

[Since the foregoing observations were published, it has occurred to us that some of the remarkable variations of increase or decrease in velocity and recoil (as shown in the accompanying tables relative to the individual powders, and in the subsequent diagram of averages) may probably have been due to differences in atmospheric pressure on the days when the respective experiments were carried out. Thus, the height of the barometer varied from 29·37in. on one day to 30·43 on another, so that there was more than an inch of difference; while the temperatures varied from 36° to 70°, or a difference of 34°. The normal atmospheric standard in this country is taken at 30in. and 60°; and at this standard the weight of the air is a fraction over 534grs. per cubic foot. When the two instruments are both below the normal standard they tend to counteract one another—a fall of about 16° with the thermometer compensating for a fall of an inch in the barometer, and *vice versa*; whereas if one rises and the other falls, there is a double pull in the same direction. Another circumstance to be taken into consideration is the fact that an increase in the weight of the atmosphere obstructs the passage of projectiles, and thus lessens their chronographic record of velocity; while the same increase of atmospheric weight adds to the work done in the expulsion of air from the barrel, and thus increases recoil. That the resistance of the air does affect both velocity and recoil, and in opposite directions, is made obvious by records taken in the vacuum experiments described on page 207, where the exhaustion of the air from the barrel had the effect of raising the muzzle velocity of the bullet by 41ft. per second, and at the same time slightly reduced the amount of recoil. If velocity and recoil had gone hand in hand, the increase in the former ought to have been accompanied by an increase of about 7 per cent. in the latter, instead of a decrease. Hence, we conclude, arise the curious zigzags in the diagram opposite, and shown more conspicuously in the fine lines representing the nitro powders than in the black lines which indicate the black powders.]

On glancing over the previous table it will be observed that with the reduction in length of barrel, the muzzle velocity gradually falls off, and recoil also diminishes. The latter diminution, however, by no means keeps in correspondence with the former; indeed, as a general rule, the more the barrel is cut down, the higher becomes the *proportion* of recoil. To prevent any misapprehension, we may state that the weight of the gun was practically unaffected by the reductions in its length; for, whenever a portion of the barrel was cut off, a piece of lead of equal weight was screwed on to the machine-rest from which the gun was fired, so that the recoiling mass remained a constant quantity throughout.

With the finer-grained black powders (No. 2 and No. 4) their greatest percentage of effective work was given with the 26in. barrel, as indicated by the black figures in the preceding table. The other powders, which were slower in combustion, showed their greatest percentage in the long barrel. With the nitro-compounds there were likewise other differences—the excess of their actual recoil over the theoretical amount being always much lower than with the black powders, when the velocities were at all alike, as will be seen on comparing the following table with its predecessor.

NITRO-COMPOUNDS.

Powder and Barrel.	Muzzle Velocity.	Theoretic Recoil.	Actual Recoil.	Excess of the Actual Recoil.	Effective Work	Atmospheric Conditions.
	Ft.sec.	Ft.lb.	Ft.lb.	Ft.lb. Per cent.	Per cent.	Barom. Inches. Thermom. Dry. Wet.
Schultze:						
34in.	1119	15·6	25·1	9·5, or 61%	62	29·90 ... 60° 53°
30 ,,	1113	15·5	26·9	11·4, or 74%	57½	30·43 ... 50° 47°
26 ,,	1075	13·8	24·9	11·1, or 81%	55½	29·57 ... 56° 51°
22 ,,	968	12·2	24·5	12·3, or 101%	49½	29·38 ... 58° 53°
18 ,,	1007	12·7	25·7	13·0, or 103%	49	29·82 ... 60° 54°
14 ,,	974	11·8	23·8	12·0, or 101%	49½	29·94 ... 59° 58°
10 ,,	826	8·5	19·4	10·9, or 127%	44	29·38 ... 52° 51°
E.C.:						
34in.	1120	15·6	25·2	9·6, or 61%	62	30·30 ... 60° 55°
30 ,,	1106	15·3	26·7	11·4, or 75%	57	30·43 ... 50° 47°
26 ,,	1033	13·3	23·0	9·7, or 73%	58	29·57 ... 57° 52°
22 ,,	964	11·6	23·2	11·6, or 100%	50	29·63 ... 68° 63°
18 ,,	982	12·0	23·4	11·4, or 94%	51½	29·82 ... 60° 55°
14 ,,	893	10·0	21·9	11·9, or 120%	45½	29·94 ... 59° 58°
10 ,,	788	7·8	19·2	11·4, or 148%	40½	29·37 ... 55° 53°
S.S.:						
34in.	1162	16·9	28·1	11·2, or 67%	60	30·30 ... 62° 51°
30 ,,	1110	15·4	27·5	12·1, or 79%	56	30·43 ... 50° 47°
26 ,,	1016	12·9	24·9	12·0, or 93%	51½	29·55 ... 55° 50°
22 ,,	991	12·3	24·7	12·4, or 102%	49½	29·40 ... 58° 52°
18 ,,	1016	12·9	26·4	12·5, or 102%	46	29·82 ... 57° 52°
14 ,,	924	10·7	23·9	13·2, or 124%	45	29·94 ... 56° 56°
10 ,,	828	8·6	21·3	12·7, or 149%	40	29·37 ... 55° 53°
J.B.:						
34in.	1101	15·1	22·0	7·0, or 45%	69	30·30 ... 64° 56°
30 ,,	1061	14·1	22·2	8·1, or 58%	63½	29·70 ... 65° 57°

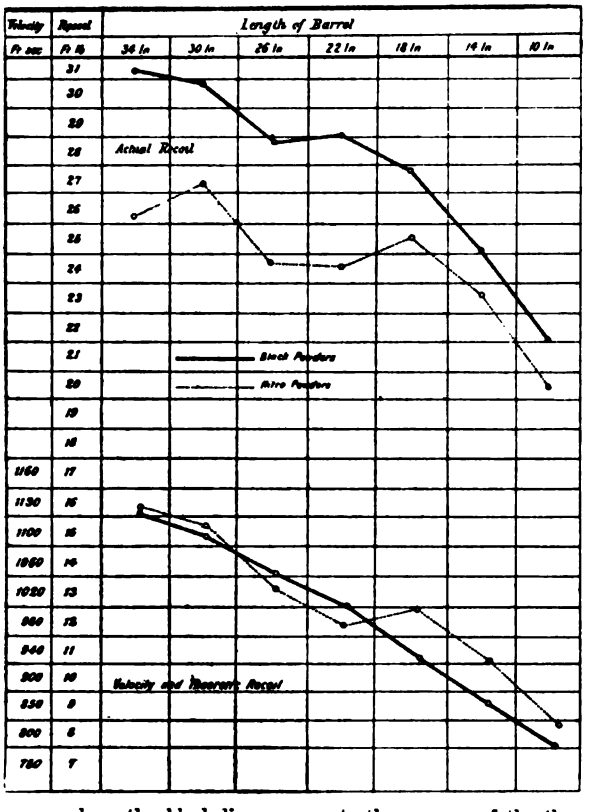
In the last of the nitro series there are only two sets of records, instead of seven, as with the others. This arose from our supply of

J.B. powder being exhausted with the 30in. experiments; and being informed, when we wished to purchase some more, that this powder was no longer supplied to the trade, we could not carry out further experiments, but here give the particulars so far as they go.

On examining the records of the nitro-compounds, it will be seen that they do not proceed so regularly as those of the black powders; and it does not appear easy to account for some of the irregularities. On various occasions, when we have not found results accord so satisfactorily as we thought they should do, we have had experiments repeated; but, in most instances, the additional trouble has been taken to very little purpose. Once we did find that some low records had been caused by the powders getting damp; and, having repeated the trials, and obtained much better results from newly-opened canisters of powder, we cancelled the old figures and substituted the new.

On a subsequent occasion, after carrying out experiments with the 18in. barrel, we found that some of the records (chiefly with nitro-compounds) showed higher velocity and recoil than had shortly before been exhibited by the 22in. barrel, although the inference derived from previous experience was that the reduction in length of barrel would produce lower instead of higher records. A repetition of the experiments was accordingly determined on; and, as the apparent anomaly was only discovered after the gun had been shortened to 18in., the barrel had to be lengthened again by carefully soldering on the 4in. last cut off. On repeating the trials this time there was nothing to confirm the suspicion of dampness; the same powders which had given high results with the 18in. barrel again gave low results at 22in.; and the chief increase was with a black powder, and not with the nitro-compounds, as expected. This unlooked for exhibition of greater velocity and recoil by the nitro powders, when the barrel was cut down to 18in., appeared very strange; yet it recalled to mind the fact that a somewhat similar circumstance occurred in experiments with ball two years before, when the barrel was about the same length.

The percentage differences of the individual powders are given in the previous tables, but the distinctive characteristics of the two classes of explosives are more graphically set forth in the following



diagram, where the black line represents the average of the three black powders, and the dotted line represents the average of the three nitro-compounds.

According to theory, a rise or fall in velocity ought to be regularly accompanied by a corresponding increase or decrease in recoil; hence the lower curves or zigzags in this diagram will apply alike to the velocities stated in round numbers in the first column of figures, and to the theoretic recoil stated alongside in the second column. At the top of the diagram, however, the actual record of recoil is shown to be much higher than the theoretical estimate given underneath. The distance separating the black line at the top from the black line at the bottom, averages about fifteen divisions (or foot-pounds) on the scale; and it seldom departs very much from this average. Between the dotted lines, however, the space averages only about ten of such divisions; but the variations are more abrupt, although the lines below, except in the first instance, rise and fall almost simultaneously with those above.

Taking into consideration the diminution of muzzle velocity that arises from the successive shortening of the barrel, it seems, at first sight, remarkable that the foregoing tables should generally show so small a reduction in the amount of recoil. The actual record always considerably exceeds the theoretical estimate of recoil, and the disparity becomes more marked as the barrel is cut down; for although the theoretical estimate falls off about one-half, owing to the diminished velocity of the shot, the "excess" *per se* varies comparatively little. There are certain differences in proportion between one kind of powder and another; yet they all, with some slight variations of detail, show the same general tendency to increase the percentage of recoil—or, in other words, to fall off in the proportion of effective work—as the length of the barrel is reduced.

It would appear as though, out of the full force generated by the explosion of the powder, an approximately constant quantity were expended in overcoming resistances that are not accounted for by merely estimating the energy that is imparted to the projectile.

The difference in recoil of the two classes of explosives seems, however, to be due to the great weight of the solid residue left by the combustion of black powders; while that of the nitro-compounds may, in comparison, be looked upon as practically *nil*. This solid residue (which is equal in weight to about 60 per cent. of the black powder charge) is ejected from the barrel in addition to the shot, and so must add to the amount of work done although it cannot exactly be considered "effective work." On making certain calculations of recoil, with 60 per cent. of the 3drs. of powder added to the weight of shot and wads,* we find that the estimate of recoil, with a 7lb. gun, is increased by almost exactly one-fifth, or 20 per cent.; and on adding this 20 per cent. to the recoil records of nitro powders, or reducing the records of black powder to the same extent, the results come out tolerably close together. The process is very easily carried out. By taking a recoil record of black powder, and dividing it by 1·2, the result appears much the same as what is given by a nitro-compound showing similar velocity. As the effects of different powders are not exactly alike in the same barrel, there will necessarily be divergences in going through the various lengths from 34in. to 10in.; but on taking the average of the whole seven lengths of barrel the results approximate pretty closely, as will be seen by the following summary:

AVERAGES OF SEVEN LENGTHS OF BARREL.

Powders.	Muzzle Velocity.	Theoretic Recoil.	Actual Recoil.	Excess of the Actual Recoil.	Effective Work.
	Ft.sec.	Ft.lb.	Ft.lb.	Ft.lb. Per cent.	Per cent.
No. 2 Black	1019	13·0	29·4	16·4, or 1·7%	44 ×1·2=53
No. 4 ,,	999	12·5	28·7	16·2, or 130%	43½×1·2=52
No. 6 ,,	910	10·3	24·2	13·9, or 134%	42½×1·2=51
Brown	904	10·2	24·4	14·2, or 139%	42 ×1·2=50½
Schultze	1015	12·9	24·3	11·4, or 89%	53
E.C.	984	12·1	23·2	11·1, or 92%	52
S.S.	1007	12·6	25·2	12·6, or 100%	50

On multiplying by 1·2 the percentage of "effective work" of black powders (as shown in the final column of this table), the product will be found similar to the results of the nitro-compounds given in the same column. To ascertain the corresponding proportion of "actual recoil," the numbers given under that head must be divided by 1·2; but the results will not come quite so close as the others, owing to the variations in velocity. The closer the velocities are, the more nearly will the recoils accord.

*Throughout these experiments, when estimating the amount of theoretic recoil, we have included the weight of the wads with that of the shot-charge, so as to render a more complete estimate of the work done. With the present charge four wads were used—a Field wad, a ⅛in. greased felt, and two white cards—and their weight (33grs.) was added to the 1⅛oz. charge of shot, with which they were projected from the gun.

We think it not improbable that some among our readers, holding to the opinion that the momentum of recoil cannot exceed the momentum imparted to the projectile, may conclude that the results recorded above are vitiated by some general error, either in the apparatus or the calculations. And we fancy we hear the remark made that "Action and reaction are equal; and you cannot set aside the laws of nature."

From our point of view, these laws have for many years been disregarded in the prevailing method of estimating recoil, which would make it appear that a portion of the action is equal to the whole of the reaction. We will therefore add a few particulars of further experiments, which do not strictly belong to the series that has given the heading to the present article, but yet may serve to throw light upon seeming anomalies. For example:

Experiment with Gun and Projectile of Equal Weight.

One of the statements commonly set forth in text-books compiled for the use of students runs to the following effect: "If a gun could be made of the same weight as the shot, the energy of recoil of the gun would be equal to the energy of the shot at the muzzle; for the powder, on being ignited, would propel the shot and the gun with equal velocity in opposite directions."

Having reason to doubt the accuracy of this assertion, we recently put it to the test. We obtained a heavy 12-bore barrel, also a solid rod of steel of equal weight, fitting fairly but not tightly in the bore; and the barrel having been loaded with powder, wads, and steel rod, the charge was fired. Instead of the two bodies of equal weight being propelled to equal distances, the barrel was driven about half as far again as the steel rod.

Fact thus appeared to be contrary to theory in this rough experiment; but we wished to procure more exact information, and accordingly proceeded anew, with the aid of the chronograph. The weight of the barrel was 4lb. 8oz.; the steel rod also weighed 4lb. 8oz., and, being about double the length of the barrel, projected far beyond the muzzle. The barrel and projectile were both supported on rollers, running on a smooth bed; and the charge (7drs. of No. 6 black powder) was ignited by means of a touch-hole. The respective velocities of the projectile and the barrel, in five rounds, are shown in the following table, which is drawn up in similar fashion to those given in the previous part of this article.

Round.	Velocity of Projectile.	Velocity of Barrel.	Energy of Projectile.	Energy of Recoil.	Excess of the Recoil.	Effective Work.
	Ft.sec.	Ft.sec.	Ft.lb.	Ft.lb.	Ft.lb. Per cent.	Per cent.
1	94 ...	117	618 ...	957	339, or 55%	64½
2	94 ...	117	618 ...	957	339, or 55%	64½
3	95 ...	113	631 ...	973	342, or 54%	65
4	95 ...	119	631 ...	990	359, or 57%	63½
5	96 ...	122	644 ...	1041	407, or 63%	62

The average velocities of the whole five rounds was 95 f.s. with the projectile and 119 f.s. with the gunbarrel; so the averages of energy, percentage, &c., may be taken as similar to the figures given for Round 4, which show that the energy of recoil was 990 ft.lb., while the energy of the projectile was but 631 ft.lb. Hence the percentage of "effective work" imparted to the projectile in this experiment (about 60%) was much the same as was shown by several of the powders with the 34in. barrel in the second table printed on page 178, and considerably less than was given by the J.B. powder in the same table.

Recoil of Gun with no Projectile.

The apparatus used for the 4½lb. barrel and 4½lb. projectile was afterwards employed in a similar manner, except that the steel rod was dispensed with, and the 7drs. charge of powder was fired without any shot. Under these circumstances, the projectile being 0, the theoretical recoil should also be 0; yet the barrel was driven backwards with a velocity of 21 ft.sec., or nearly the same in amount as the difference between the speed of the barrel and that of the steel rod, as the former exceeded the latter by more than 22 ft.sec.

The explanation we take to be simply this: After the projectile has left the gun, the powder gases still add to the recoil; they continue to act in the barrel in like manner as in a rocket, and the process of action and reaction thus goes on until the pressure of the gases in the barrel is reduced to about 15lb. per square inch, when an equilibrium is established with the air outside. The weaker the body of gas in the barrel, at the moment of the shot's exit, the less is the excess of actual recoil over the theoretical amount.

This seems to be proved by an increased ratio of recoil when more powder is used; also by experiments in which a perforated barrel was substituted for one reduced in length. With the unperforated barrel, however much it may be shortened, the gas already formed therein must be ejected through the muzzle; and, reaction being in the opposite direction, it thus adds to the recoil. But in the perforated barrel, so much of the gas as escaped through the perforations did not add to the recoil. The holes being made in opposite pairs, the one counteracted the other; if they had been only on one side, the barrel would have been jerked in the opposite direction.

The result, with the shortened barrel, was that the percentage of recoil *increased* as the length of the tube was reduced; whereas, with the perforated barrel, the percentage of recoil *decreased* when the perforations were nearer to the breech. And when the charge of powder was lessened, the recoil diminished in much greater ratio than the speed. The perforations began at 3in. from the muzzle, four ⅝in. holes being drilled through the wall of the barrel in opposite pairs,—one pair being above and below, and the others on the right and left sides. Five series of holes were thus made, 3in. apart, in a barrel that was 31in. long. Spherical ball, weight 525grs., was used with 3drs. of No. 4 black powder, one 11⅜ Field wad, ⅝in. felt, and two white cards. After the last round had been fired with 3drs. of powder, a round was fired with 2drs. and another round with 1dr. The results are shown below:

Gunbarrel and Powder.	Muzzle Velocity.	Theoretic Recoil.	Actual Recoil.	Excess of the Actual Recoil.
3 drs. No. 4 Black:	Ft.sec.	Ft.lb.	Ft.lb.	Ft.lb. Per cent.
Unperforated barrel..	1067	14·2 ...	31·3	17·1, or 120½%
Perforated at 28in. ...	1054	13·9 ...	30·5	16·6, or 120%
,, ,, 25in. ...	1036	13·4 ...	29·3	15·9, or 119%
,, ,, 22in. ...	1026	13·1 ...	25·5	12·4, or 94%
,, ,, 19in. ...	1018	12·9 ...	23·4	10·5, or 81%
,, ,, 16in. ...	1004	12·6 ...	21·9	9·3, or 74%
Reduced charges:				
2 drs. (at 16in.)	816	8·3 ...	12·9	4·6, or 55%
1 dr. (ditto).....	520	3·4 ...	4·9	1·5, or 45%

When the only perforations in the barrel were near to the muzzle, where the bullet would be moving with great rapidity, very little time would be allowed for the escape of gas; and the percentage of recoil consequently shows very little diminution. But as the number of holes increased, and were made nearer and nearer to the breech, greater facilities were afforded for the gas to escape; and there being much less outrush of gas when the bullet left the muzzle, the recoil diminished accordingly. With the reduction of the powder-charge there would, of course, be a further limitation in the outrush of gas from the muzzle; and there was a consequent diminution in the percentage of recoil.

Effect of Friction of the Shot.

That the friction of the projectile also has great influence over the recoil of the gun has been demonstrated by other experiments, in which the employment of loose shot (owing to the strong grip the pellets take on the barrel, and the facilities they afford for increasing or diminishing the charge) has the effect of producing more distinctive evidence than could be obtained from steel rods or other solid projectiles. But this article is already so long that we will only briefly state the results.

A very heavy load of No. 6 shot being used, together with a large charge of powder, the barrel, on the charge being fired, recoiled for a distance of about a foot, when it halted, and then moved forward again to near the point from which it had recoiled. We conclude that the friction of the shot, as it approached the muzzle, overmastered to some extent the diminishing force of the powder-gases, but that the momentum already imparted to the shot, aided by the remaining pressure of the gas, enabled the pellets to push their way out of the tube.

On the proportions of powder and shot being altered, the extent of the recoil and subsequent forward movement was also varied. The barrel did not move at all when a charge of powder (3drs.) was insufficient to move the shot in the bore; and the gases then made their exit out of the touchhole. When the quantity of powder sufficed to overcome the friction for some part of the distance in the barrel, but failed to keep it up as the gases became reduced in strength, the shot, of course, stopped in the tube. Its momentum, however, was not annihilated, but was transferred to the barrel, which, with the shot wedged inside, was then carried forward with such force that the muzzle was driven many inches into the solid clay

at the end of the trench wherein these experiments were tried; and there the gases continued to fizz out of the touchhole until the whole of the powder was exhausted.

Looking at such facts, one may unedrstand that, in a very long gunbarrel, the continuous friction of the shot-charge, as the force of the powder approaches its minimum, may have a double influence—by restricting the speed of the shot, and by serving as a sort of "brake" to the recoil of the gun. Such would seem to have occurred with the 34in. barrel and some of the powders mentioned in the foregoing tables.* But the effects were not uniform with all explosives. With one powder, the recoil was the same with a shortened barrel as it had been before it was cut down, although the velocity of the shot was reduced. In other instances, velocity fell off and recoil increased. And when the right and left barrel of the same gun were tried under exactly the same conditions, the recoil recorded by the choke was always less than that recorded by the cylinder barrel, although the chronograph showed the former to have given higher velocity to the shot. P.—T.

[The subject of recoil generally is treated more fully in articles reprinted hereafter at pages 197 *et seq.*]

TRIAL OF "VENA-CONTRACTA" GUNS.

(*Field*, Oct. 10, 1896; Vol. 88, p. 580.)

THE 12-20 GAUGE.

WHEN we were publishing details of the performances of a number of 12, 16, and 20-bore guns (reprinted, *ante*, at pages 125 to 168), it was suggested by several correspondents that we should likewise give similar particulars relative to the performance of a Vena-Contracta gun. This we promised to do, and one gentleman kindly offered to send his own gun for trial. We accepted the offer, but we did not carry out the trial at once, as the present proprietors of the Vena-Contracta patent (Messrs Joseph Lang and Son, of Pall Mall) requested us to also test two modifications of the original gun which they were making; and hence the delay in carrying out the trial.

It will doubtless be remembered by most of our readers that the principle of the "Vena-Contracta" is that the chamber is of the usual 12-bore dimensions, but the bore of the gun is gradually contracted, until at the muzzle it is only of 20-gauge. Consequently the shot and wads with which the 12-bore cartridge is loaded become compacted more and more tightly as they are driven through the barrel. The alteration introduced by Messrs Lang is to vary the size of the bore at the muzzle, so that, although in each gun an ordinary 12-bore cartridge may be used, the size of bore at the exit may be made of 16 or 18 gauge, instead of 20 gauge as in the guns hitherto constructed on this principle.

We have now tried the three guns, viz., 12-20, 12-18, and 12-16 bores, and here publish the records with the one first mentioned. This is the gun which was lent to us by a gentleman resident in the county of Durham. It is a little heavier than the guns ordinarily made on this principle, which are generally about 6lb. in weight, as the lightness of the barrel towards the muzzle permits of greater thickness of metal being given near the breech. In the present instance, however, the owner of the gun had it especially made somewhat heavier than usual, in consequence of his being a sufferer from gun-headache.

VENA-CONTRACTA GUN (12—20 BORE), with 1¼oz. shot.

Barometer 30·10 inches; Thermometer—Dry 61°, Wet 61°.

Gun No. 8371; weight 6lb. 5oz.; barrels 30in.

RIGHT BARREL.—Powder (Shot-Gun Rifleite), 38grs.; shot, 1¼oz. (304 pellets) No. 6. Gas pressure, average 1·92 tons per square inch.

	40 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Ft.sec.	Recoil. Ft.lb.
1	36	22	25	19	16	16	102	202	1136	27·2
2	45	30	28	26	18	17	139	175	1167	29·7
3	49	28	33	24	23	16	134	170	1158	29·1
4	46	32	30	27	20	18	135	169	1141	28·6
5	43	35	31	25	22	21	134	170	1145	27·9
6	49	28	33	23	18	15	133	171	1154	28·9
7	51	33	32	21	16	19	137	167	1149	29·1
8	33	26	25	24	20	21	108	196	1154	29·2
9	43	32	21	20	18	20	121	183	1163	29·5
10	49	32	29	26	18	15	136	168	1141	28·8
Aver...	45	30	29	23	19	18	127	177	1151	28·3

	30 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	99	66	48	25	16	13	238	66		
2	68	58	29	26	19	12	181	123		
3	113	61	40	19	13	14	233	71		
4	88	53	32	21	18	12	194	110		
5	96	66	45	28	20	17	235	69		
6	104	56	47	24	14	11	231	73		(As before.)
7	85	65	44	27	17	15	221	83		
8	124	63	39	16	10	11	242	62		
9	107	59	45	23	15	11	234	70		
10	99	64	41	28	11	14	232	72		
Aver...	98	61	41	24	15	13	224	80		

	20 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	188	56	21	9	6	7	274	30		
2	165	52	23	15	10	9	255	49		
3	143	44	21	17	12	12	225	79		
4	172	58	26	12	7	8	268	36		
5	149	66	19	13	9	6	247	57		
6	186	50	22	10	10	7	268	36		(As above.)
7	170	56	27	7	3	6	260	44		
8	163	61	24	16	11	8	264	40		
9	168	47	18	18	8	2	251	53		
10	183	58	20	11	7	5	271	33		
Aver...	169	55	22	13	8	7	259	45		

LEFT BARREL.—Charge of powder, 38grs.; shot, 1¼oz. (304 pellets) No. 6 shot.

	40 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	60	42	33	26	20	15	161	143		
2	44	38	31	30	19	16	143	161		
3	57	46	28	27	21	14	158	146		
4	55	44	32	25	15	20	156	148		
5	59	40	35	27	17	11	161	143		
6	46	40	29	31	23	20	146	158		(As above.)
7	57	45	34	29	20	18	165	139		
8	44	48	31	27	19	17	150	154		
9	52	37	27	33	18	21	149	155		
10	48	50	32	28	16	14	158	146		
Aver...	52	43	31	28	19	17	154	150		

	30 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	125	68	36	17	14	14	246	58		
2	118	64	34	26	17	11	242	62		
3	125	53	28	28	10	7	234	70		
4	120	59	30	22	18	18	231	73		
5	67	43	38	27	16	10	175	129		
6	122	60	29	25	17	12	236	68		(As above.)
7	88	53	26	28	14	9	195	109		
8	118	66	39	22	12	10	245	59		
9	120	61	32	26	18	8	239	65		
10	106	59	35	31	19	14	231	73		
Aver...	111	59	33	25	16	11	227	77		

	20 YARDS PATTERN.									
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	156	54	28	11	8	9	249	55		
2	183	58	20	15	10	7	276	28		
3	190	44	16	12	7	4	262	42		
4	175	63	25	15	8	6	278	26		
5	178	66	17	13	5	3	274	30		
6	188	52	22	16	9	5	278	26		(As above.)
7	133	56	33	12	11	8	234	70		
8	192	48	24	10	8	4	274	30		
9	174	57	25	13	4	5	269	35		
10	186	55	22	14	7	8	277	27		
Aver...	176	55	23	13	8	6	267	37		

* In another experiment, tried with a barrel 45 inches in length, the recoil was much reduced, as described in an article published on page 96.

VENA-CONTRACTA GUN (12—20 BORE), with 1oz. shot.
Barometer 30·10 inches; Thermometer—Dry 62°, wet 59°.

RIGHT BARREL.—Charge of powder, 37grs.; shot, 1oz. (270 pellets) No. 6. Gas pressure, average 1·82 tons per square inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Ft.sec.	Recoil. Ft.lb.
1	46	32	27	29	11	18	134	136	1154	24·0
2	58	36	28	25	16	15	147	123	1167	24·5
3	47	35	30	14	20	13	126	144	1149	23·9
4	33	27	28	17	18	13	105	165	1145	23·5
5	52	34	32	23	17	18	141	129	1172	24·7
6	65	37	27	20	11	14	149	121	1154	24·2
7	50	32	29	26	19	12	137	133	1132	23·6
8	44	35	33	21	15	17	133	137	1158	24·8
9	49	38	26	24	18	16	137	133	1141	23·7
10	47	34	31	28	25	19	140	130	1167	24·6
Aver...	49	34	29	23	17	16	135	135	1154	24·2

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	58	39	31	25	19	15	153	117	
2	83	61	27	23	16	12	194	76	
3	99	56	29	25	7	11	209	61	
4	85	64	31	22	13	13	202	68	
5	80	58	35	26	17	15	199	71	
6	73	62	29	23	15	13	186	84	(As above.)
7	99	62	33	20	12	8	214	56	
8	91	59	30	27	18	11	207	63	
9	44	28	34	25	27	15	131	139	
10	77	65	32	28	13	10	202	68	
Aver...	79	55	31	24	16	12	189	81	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	116	55	32	16	9	9	219	51	
2	130	48	31	18	12	7	227	43	
3	148	53	15	5	4	0	221	49	
4	122	50	31	11	9	5	214	56	
5	101	46	33	19	14	11	199	71	
6	135	52	22	17	11	6	226	44	(As above.)
7	160	40	18	3	2	3	221	49	
8	108	58	29	12	10	8	207	63	
9	152	42	20	6	7	5	220	50	
10	110	57	36	16	16	7	219	51	
Aver...	128	50	27	12	9	6	217	53	

LEFT BARREL.—Powder, 36grs.; 1oz. No. 6 shot (270 pellets).

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total. in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	52	36	34	23	14	11	145	125	
2	59	40	32	21	16	13	152	118	
3	60	42	40	25	9	20	167	103	
4	67	39	37	23	17	14	166	104	
5	54	47	31	21	12	12	153	117	
6	65	38	33	22	14	9	158	112	(As above.)
7	58	47	37	26	18	15	168	102	
8	63	44	34	23	15	12	164	106	
9	57	45	36	20	13	10	158	112	
10	61	43	34	24	16	15	162	108	
Aver...	60	42	35	23	14	13	159	111	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	89	66	39	15	12	11	209	61	
2	84	62	33	24	16	14	203	67	
3	95	53	34	18	9	9	200	70	
4	93	64	29	22	12	10	208	62	
5	59	57	40	20	14	23	176	94	
6	91	62	32	18	11	11	203	67	(As above.)
7	88	52	28	23	15	14	191	79	
8	67	43	24	19	17	7	153	117	
9	82	65	33	25	13	10	205	65	
10	98	54	28	21	15	12	201	69	
Aver...	85	58	32	21	13	12	195	75	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	162	50	19	12	9	7	243	27	
2	154	42	20	11	5	4	237	43	
3	155	55	32	7	6	6	249	21	
4	163	46	19	8	4	5	236	34	
5	170	38	17	9	1	3	234	36	
6	172	50	16	12	2	3	250	20	(As above.)
7	163	51	17	6	7	5	237	33	
8	148	54	21	8	5	6	231	39	
9	185	40	17	3	3	2	245	25	
10	151	53	24	10	7	6	238	32	
Aver...	162	48	20	9	5	5	239	31	

SIZE OF RINGS ON THE TARGET.

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36¼ "

} The area of each belt, between two rings, is the same as above.

THE 12-18 AND 12-16 VENA-CONTRACTA GUNS.

Field, Oct. 17, 1896; Vol. 88, p. 611.

THE particulars given in the previous article, relative to the trial of a 12-20 gun, showed that there was not much difference in the target results when compared with those of an ordinary 12-bore using similar cartridges. And the records of the 12-18 and 12-16 guns, now given, indicate that their characteristics are very similar to those of the 12-20, though exhibited in a somewhat less degree, as might naturally be expected from the diminished contraction of the bore.

When the Vena-Contracta was first brought out, it was suggested that the reduction of the bore as it proceeded up the barrel would considerably increase the pressure of the powder gases. This seemed a not unnatural conclusion; but some experiments then carried out in our own 12-bore crusher-gauge (with certain modifications made therein to adapt it to the alteration of circumstances) did not show that there was any material increase in the pressures as compared with those of ordinary 12-bore barrels. We have been glad, however, of the present opportunity of investigating the subject more thoroughly, as Messrs Joseph Lang and Son, the makers of the three guns, have placed at our service three new crusher-gauges, which they had constructed for their own use, and these have been made in exact accordance with the interior of the guns, viz., 12-20, 12-18, and 12-16 gauges respectively, their internal parts having been bored with the same tools as were used for the guns. That is to say, the barrel is reduced to its final dimensions in the first six inches from the end of the chamber; so that the shot and wads are gradually compressed while their velocity is comparatively low; and thence forward the barrel proceeds to the muzzle in similar form to that of an ordinary gun of 16, 18, or 20 bore, as the case may be.

The records obtained by firing ten rounds in each of the three new crusher-gauges, with 1⅛oz. of shot, and the pressures given in our own 12-bore crusher-gauge with some of the same batch of cartridges, were as follows:

Bores.	Pressures in Tons per square inch.									
12-20	1·79	1·91	1·91	2·10	1·79	1·87	1·95	2·00	1·79	2·14
12-18	2·00	1·78	1·73	2·00	1·88	1·73	1·63	1·88	1·92	1·73
12-16	2·00	1·88	1·68	1·92	1·83	2·04	1·63	2·04	1·78	1·96
12-bore	1·63	1·78	1·53	1·92	1·53	1·88	1·92	1·78	1·73	1·53

The charge of powder used in the 12-20 gun was 38grs.; but in the other three guns it was one grain less. The reason of this difference was that 37grs. sufficed to give the standard velocity of 1160 ft.sec. in the 12-18 and 12-16 bores, but was not enough in the more contracted barrel, and consequently 38grs. were used.

As may be found above, the most contracted barrel exhibited the highest amount of pressure, and the ordinary 12-bore showed the least amount; but the facts are not quite so evident in the foregoing table as in the following summary, where we give the lowest and highest rounds in each series of ten, together with the averages. We also state the pressures with 1oz. of shot as well as with 1⅛oz., except in the 12-bore, in which the smaller charge was not tested. With the 1oz. charge of shot, the powder was reduced by one grain.

PRESSURES IN TONS PER SQUARE INCH.

Bores.	With 1⅛oz. Shot. Lowest round.	Highest round.	Average of ten.	With 1oz. Shot. Lowest round.	Highest round.	Average of ten.
12-20	1·79	2·10	1·92	1·62	2·10	1·82
12-18	1·63	2·00	1·82	1·53	1·96	1·70
12-16	1·63	2·04	1·88	1·47	1·96	1·74
12-bore	1·53	1·92	1·72	—	—	—

The averages of pressure in the Vena-Contracta guns are a little higher than in the ordinary 12-bore; but the difference between the highest average and the lowest is not nearly so great as the variations that occur with successive cartridges fired from the same gun, and which variations are apparently due merely to differences in strength of the caps.

Next we give the patterns. Here it may be observed that the three contracted guns differ somewhat in their boring. The 12-20 is a cylinder in the right barrel and medium choke in the left; the other two are medium choke in both barrels. The ordinary 12-bore record is copied from a trial of the same powder published in the *Field* of July 4, 1896. The gun is a rather full choke in the left barrel, which alone was used, and one wild shot will account for the small pattern in the lowest round; the rest were pretty regular.

PATTERNS IN 30-INCH CIRCLE AT 40 YARDS.

Bores.		With 1⅛oz. of Shot. Lowest round.	Highest round.	Average of ten.	With 1oz. of Shot. Lowest round.	Highest round.	Average of ten.
12-20	R.	102	137	127	105	149	135
	L.	143	165	154	145	168	159
12-18	R.	140	177	165	126	158	145
	L.	144	170	161	122	145	138
12-16	R.	128	192	172	118	170	159
	L.	142	236	183	134	171	162
12-bore	L.	76	230	193	—	—	—

Now we come to the velocities, which were as follows:

VELOCITIES IN FEET PER SECOND.

Bores.	With 1⅛oz. Shot. Lowest round.	Highest round.	Average of ten.	With 1oz. Shot. Lowest round.	Highest round.	Average of ten.
12-20	1136	1167	1151	1132	1172	1154
12-18	1149	1186	1168	1145	1190	1170
12-16	1132	1186	1166	1149	1190	1169
12-bore	1141	1195	1171	—	—	—

In these records, the velocities do not vary so much with the contracted guns as with the ordinary 12-bore. But we do not think that any importance is to be attached to this circumstance, as we believe that variations of velocity from round to round depend not so much either upon the gun or the powder as upon the strength of the caps. There is one remarkable fact, however, in connection with the most contracted gun—the 12-20—and that is, that although it had 38grs. of powder, instead of 37grs., as in the other three guns, this increase did not bring the velocity quite up to the standard of 1160 ft.sec.; and when the powder was further increased, there was practically no increase in the velocity.

The recoil records also show some interesting results. At the first glance it would appear as if the recoil with the 12-20 bore is much the same as that of the ordinary 12-bore; but the fact has to be taken into consideration that the weight of the 12-bore is 7lb., whereas that of the 12-20 is but 6lb. 5oz., and the other two are unfinished guns, that have not been reduced to their ultimate weight, which will probably be about 6lb. In order to compare the results fairly, the weights should be alike, and we have therefore recalculated the records on the supposition that the four guns weigh exactly 6lb. each.

The *raison d'être* of the contracted method of boring is to provide strong guns of light weight, without shortening the barrels, as is often done with light-weight guns. By reducing the size and weight of the barrel forward, greater thickness of metal can be given at the breech and less weight is required in the stock in order to balance the gun. But a light gun must necessarily give more recoil than a heavy one, when charges and velocity are the same; and to test these guns on their merits it is requisite to show what is the full amount of recoil with their regular weight. Accordingly we have taken 6lb. for all four guns, whatever the bore, and on that basis the recoil records stand as follows:

RECOIL IN FOOT-POUNDS (Guns, 6lb. each).

Bores.	With 1⅛oz. Shot. Lowest round.	Highest round.	Average of ten.	With 1oz. Shot. Lowest round.	Highest round.	Average of ten.
12-20	28·6	31·3	30·3	24·7	26·1	25·5
12-18	28·9	31·0	29·9	24·7	27·2	26·2
12-16	28·4	31·0	30·1	24·9	27·5	26·5
12-bore	31·8	35·9	33·2	—	—	—

Here it will be seen that the ordinary 12-bore gave about 10 per cent. more recoil than either of the Vena-Contracta guns with the 1⅛oz. charge of shot. (There was no trial of the smaller charge in the 12-bore.) The three contracted guns gave results which were close together; and although the 12-20 showed a little more recoil than its two *confrères*, that may be accounted for by its having a rather larger charge of powder. With the 1oz. charge of shot, the 12-20 gave least recoil; and it may be inferred that the higher recoil with the other two was due to their barrels being less contracted, as the greater the amount of friction, and consequent check to the forward movement of the shot, the greater would be the retardation to the backward movement of the gun.

VENA-CONTRACTA GUN (12-18 Bore), with 1⅛oz. shot.

Barometer, 29·83; Thermometer—Dry 61°, Wet 61°.

Weight of gun, 6lb. 9oz.; length of barrels, 30in.

RIGHT BARREL.—Powder (Shot-gun Rifleite), 37grs; shot, 1⅛oz. No. 6 (304 pellets). Gas pressure, average 1·82tons per sq. inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	64	49	33	20	17	18	166	138	1181	27·4
2	76	51	28	22	19	13	177	127	1167	27·2
3	62	55	30	17	18	15	164	140	1172	28·0
4	67	50	32	21	15	13	170	134	1149	26·0
5	73	46	35	20	19	17	174	130	1167	27·0
6	58	50	38	22	14	14	168	136	1154	26·8
7	70	52	26	18	16	13	166	138	1176	27·6
8	75	47	31	21	18	11	174	130	1158	26·4
9	52	41	23	24	25	23	140	164	1172	28·3
10	58	44	31	14	20	16	147	157	1186	28·2
Aver...	66	48	31	20	18	15	165	139	1168	27·3

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	111	65	38	22	16	10	236	68	
2	99	59	42	30	12	10	230	74	
3	104	61	35	28	18	14	228	76	
4	76	69	42	24	12	10	211	93	
5	116	55	34	26	17	12	231	73	
6	95	62	40	23	19	16	220	84	(As above.)
7	120	57	35	15	14	14	227	77	
8	92	60	41	22	16	12	215	89	
9	96	59	46	25	18	18	226	78	
10	122	56	37	21	15	11	236	68	
Aver...	108	60	39	24	16	13	226	78	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	171	51	14	12	6	12	248	56	
2	162	57	30	16	11	6	265	39	
3	170	50	26	13	9	7	259	45	
4	168	48	22	11	8	4	249	55	
5	159	59	34	18	13	10	270	34	
6	177	44	28	9	7	4	258	46	(As above.)
7	180	52	20	12	3	5	264	40	
8	164	46	32	15	8	10	257	47	
9	183	38	21	6	6	4	248	56	
10	179	55	26	11	10	7	271	33	
Aver...	171	50	25	12	8	7	259	45	

LEFT BARREL.—Powder, 37grs; 1⅛oz. No. 6 shot (304 pellets).

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle	Outside 30in.	Velocity & Recoil.
1	46	42	30	26	24	12	144	160	
2	59	41	39	23	18	16	162	142	
3	65	48	35	17	16	12	165	139	
4	60	43	37	24	18	19	164	140	
5	55	40	38	21	19	16	154	150	
6	63	46	35	30	15	12	164	140	(As above.)
7	56	40	40	27	16	20	163	141	
8	54	47	37	25	19	17	163	141	
9	66	45	33	26	20	14	170	134	
10	58	42	36	29	22	16	165	139	
Aver...	58	43	36	24	19	15	161	14	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	87	44	42	25	25	12	198	106	
2	99	58	36	27	20	15	220	84	
3	109	51	30	21	18	13	211	93	
4	92	56	41	23	18	13	212	92	
5	96	66	39	25	21	10	236	78	
6	105	64	35	28	16	7	232	72	(As above.)
7	84	55	43	26	22	15	208	96	
8	101	61	38	30	19	12	230	74	
9	96	57	30	24	18	17	207	97	
10	111	60	31	22	20	14	224	80	
Aver...	98	57	37	25	20	13	217	87	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	142	58	29	23	11	7	251	53	
2	135	53	30	27	9	10	245	59	
3	148	60	28	15	7	5	251	53	
4	151	47	32	20	5	4	250	54	
5	133	55	29	24	12	10	240	64	
6	152	45	32	28	10	6	257	47	(As above.)
7	144	69	21	17	9	3	245	59	
8	160	55	23	9	3	5	247	57	
9	161	49	19	12	8	6	241	63	
10	156	66	25	8	7	3	255	49	
Aver...	148	55	27	18	8	6	248	56	

VENA-CONTRACTA GUN (12-18 BORE), with 1oz. shot.

RIGHT BARREL.—Powder, 36grs.; shot, 1oz. No. 6 (270 pellets).

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	61	37	27	27	13	14	152	118	1176	24·5
2	56	33	30	23	21	16	142	128	1186	24·7
3	53	37	29	19	19	12	138	132	1154	23·0
4	58	38	27	24	17	13	147	123	1163	24·0
5	64	39	29	26	15	17	158	112	1172	23·8
6	45	36	25	20	21	20	126	144	1145	22·6
7	50	40	28	24	16	15	142	128	1172	24·5
8	62	36	30	25	18	14	153	117	1167	23·9
9	57	35	29	22	13	9	143	127	1190	24·9
10	55	37	31	26	19	16	149	121	1172	24·2
Aver...	56	37	28	24	17	15	145	125	1170	24·0

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	74	57	43	20	20	13	194	76	
2	104	48	30	15	6	10	197	73	
3	98	46	42	21	18	16	207	63	
4	111	52	33	19	14	10	215	55	
5	107	44	29	13	16	12	192	78	
6	98	54	36	16	13	11	199	71	(As above.)
7	86	57	45	23	17	15	211	59	
8	102	35	38	18	11	14	193	77	
9	99	50	41	19	11	8	209	61	
10	108	42	27	21	15	12	198	72	
Aver...	98	49	36	18	14	12	201	68	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	148	55	24	19	7	9	246	24	
2	109	70	35	26	11	10	240	30	
3	115	68	27	23	13	11	233	37	
4	176	49	13	6	6	8	244	26	
5	143	44	30	18	11	9	235	35	
6	165	50	18	10	9	4	243	27	(As above.)
7	128	72	26	20	8	7	246	24	
	180	35	14	2	5	4	231	39	
9	127	63	32	21	14	6	243	27	
10	131	74	24	13	6	7	242	28	
Aver...	142	58	24	16	9	7	240	30	

LEFT BARREL.—Powder (Shot-Gun Rifleite), 36grs.; 1oz. No. 6 shot (270 pellets).

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	44	22	29	27	20	18	122	148	
2	60	31	27	26	17	15	144	126	
3	55	25	31	24	21	22	135	135	
4	58	36	25	23	16	19	141	129	
5	50	34	32	20	18	11	136	134	
6	57	30	26	25	16	18	138	132	(As above.)
7	59	35	28	23	20	16	145	125	
8	51	33	29	26	19	14	139	131	
9	60	33	30	16	11	17	139	131	
10	56	30	32	25	17	15	143	127	
Aver...	55	31	29	23	17	16	138	132	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	86	55	27	23	14	7	191	79	
2	105	59	26	18	8	5	206	62	
3	92	53	30	23	16	10	198	72	
4	65	36	24	21	18	20	146	124	
5	91	53	25	24	18	11	193	77	
6	107	56	28	16	11	8	207	63	(As above.)
7	98	49	26	20	19	12	193	77	
8	102	63	24	22	17	14	210	60	
9	88	58	29	19	15	13	194	76	
10	84	65	23	17	11	9	189	81	
Aver...	92	55	26	20	15	11	193	77	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	143	50	27	18	12	4	258	32	
2	161	44	19	13	8	6	237	33	
3	132	46	31	13	9	8	222	48	
4	159	39	19	11	10	6	223	42	
5	140	50	30	16	15	10	236	34	
6	148	38	25	14	11	8	225	45	(As above.
7	157	42	21	12	8	6	232	38	
8	131	53	30	15	13	7	239	41	
9	169	28	14	9	11	2	220	50	
10	142	45	28	17	14	9	232	38	
Aver...	148	44	24	14	11	7	230	40	

VENA-CONTRACTA GUN (12-16 BORE), with 1⅛oz. Shot.

Barometer, 30·00 inches; Thermometer—Dry 65°, Wet 64°.

Gun No. 544; weight 6lb. 9oz.; barrels, 30in.

RIGHT BARREL.—Powder (Shot-gun Rifleite), 37grs.; shot, 1⅛oz. No. (304 pellets). Gas pressure, average 1·88 tons per sq. inch.

40 YARDS PATTERN

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	60	43	41	33	27	20	177	127	1154	27·1
2	41	32	28	27	19	25	128	176	1186	28·2
3	66	50	31	30	24	17	177	127	1145	27·0
4	79	46	33	34	18	22	192	112	1181	28·3
5	47	34	33	27	17	25	141	163	1176	27·6
6	71	52	29	28	20	18	180	124	1163	28·1
7	69	53	36	25	14	25	183	121	1132	26·0
8	63	45	37	30	22	21	175	129	1181	28·0
9	75	51	35	27	18	23	188	116	1167	27·8
10	58	46	44	35	26	17	183	121	1172	27·2
Aver...	63	45	35	29	20	21	172	132	1166	27·5

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	53	47	35	35	25	17	170	134	
2	101	55	40	19	14	7	215	89	
3	125	64	38	22	11	9	249	55	
4	127	70	35	20	8	6	252	52	
5	57	48	50	37	17	21	192	112	
6	124	74	27	18	9	5	243	61	(As above.)
7	119	59	43	24	13	13	245	59	
8	122	63	31	19	15	10	235	69	
9	127	66	41	23	9	8	257	47	
10	109	56	39	25	18	14	229	75	
Aver...	106	60	38	24	14	11	228	76	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	161	71	18	11	7	5	261	43	
2	197	39	15	6	1	4	257	47	
3	170	58	20	12	9	7	260	44	
4	160	74	26	14	6	0	274	30	
5	158	66	24	16	10	7	264	40	
6	198	45	10	8	2	4	261	43	(As above.)
7	174	62	21	14	7	5	271	33	
8	195	54	10	5	1	2	264	40	
9	201	49	12	4	3	1	266	38	
10	164	75	23	9	5	3	271	33	
Aver.	178	59	18	10	5	4	265	39	

LEFT BARREL.—Powder, 37grs.; shot, 1⅛oz. No. 6 (304 pellets).

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	91	52	27	23	17	15	193	111	
2	75	44	35	27	20	20	181	123	
3	82	56	30	21	18	17	189	115	
4	71	48	38	25	21	14	183	122	
5	67	53	51	24	15	18	195	109	
6	77	50	40	20	19	11	187	117	(As above.)
7	80	44	37	24	20	16	185	119	
8	62	29	29	22	16	17	143	162	
9	104	66	35	21	10	12	226	78	
10	59	36	28	28	18	20	151	153	
Aver.	77	48	35	23	17	16	183	121	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	84	61	42	24	23	14	211	93	
2	130	71	29	21	13	9	251	53	
3	99	75	44	27	18	11	245	59	
4	127	69	38	25	20	15	259	45	
5	43	44	35	21	17	25	143	161	
6	134	53	37	19	12	9	243	61	(As above.)
7	100	70	48	24	13	12	244	60	
8	136	58	34	20	16	10	248	56	
9	124	67	36	23	14	9	250	54	
10	133	70	33	17	11	8	253	51	
Aver.	111	64	38	22	16	12	235	69	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	218	39	11	7	5	4	275	29	
2	209	45	17	11	2	2	282	22	
3	196	47	20	9	3	4	272	32	
4	213	38	17	13	6	2	281	23	
5	206	46	10	4	3	1	266	38	
6	202	42	19	12	5	3	275	29	(As above.)
7	172	44	20	15	12	14	251	53	
8	227	39	4	5	4	4	275	29	
9	188	47	22	12	7	6	269	35	
10	225	39	10	5	2	2	279	25	
Aver.	206	43	15	9	5	4	273	31	

VENA-CONTRACTA GUN (12-16 BORE), with 1oz. Shot.

RIGHT BARREL.—Powder, 36grs.; shot, 1oz. No. 6 (270 pellets). Gas pressure, average, 1·74 tons per square inch.

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	61	42	32	19	14	18	154	116	1172	24·0
2	70	48	28	22	17	14	168	102	1163	24·2
3	63	52	35	20	19	18	170	100	1186	24·8
4	72	43	32	22	18	16	169	101	1154	23·0
5	51	27	25	15	12	15	118	152	1167	24·7
6	68	49	30	21	16	12	168	102	1181	24·6
7	63	55	33	17	13	17	167	103	1158	23·3
8	60	48	29	20	18	20	157	113	1190	25·1
9	65	47	22	24	16	19	159	112	1149	22·8
10	72	43	26	19	15	15	160	110	1172	24·5
Aver.	65	45	29	20	16	16	159	111	1169	24·1

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	123	49	31	17	13	11	220	50	
2	100	55	36	20	11	9	211	59	
3	91	58	43	13	9	6	205	65	
4	76	53	23	16	11	12	168	102	
5	109	61	38	19	15	11	227	43	
6	128	43	29	18	3	9	218	52	(As above.)
7	95	60	35	20	10	7	210	60	
8	116	59	40	14	6	5	229	41	
9	105	54	33	21	9	10	213	57	
10	121	54	36	15	12	8	226	44	
Aver.	106	55	34	17	10	9	212	58	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	123	49	28	22	22	15	221	49	
2	166	51	15	10	8	4	242	28	
3	185	34	12	6	1	2	237	33	
4	179	48	9	4	5	1	240	30	
5	159	56	17	12	7	5	244	26	
6	161	44	20	8	9	7	233	37	(As above.)
7	188	41	14	3	2	0	246	24	
8	157	55	13	9	5	6	234	36	
9	163	59	10	10	6	2	242	28	
10	161	44	19	12	9	5	236	34	
Aver.	164	48	16	10	7	5	238	32	

LEFT BARREL.—Powder, 36grs.; shot, 1oz., No. 6 (270 pellets).

40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	60	41	33	25	18	15	159	111	
2	68	50	28	18	15	13	164	106	
3	52	44	30	34	18	14	160	110	
4	71	48	32	19	16	12	170	100	
5	68	47	27	28	19	16	164	106	
6	73	51	35	11	14	11	170	100	(As above.)
7	69	44	33	20	17	13	166	104	
8	52	29	31	22	25	16	134	136	
9	70	53	32	16	16	12	171	99	
10	66	45	23	24	20	15	163	107	
Aver.	65	45	31	21	18	14	162	108	

30 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	128	53	30	18	8	5	224	46	
2	95	58	36	22	13	10	211	59	
3	114	54	33	19	7	8	220	50	
4	127	53	24	15	8	7	219	51	
5	97	55	34	21	12	10	207	63	
6	123	49	32	18	9	6	222	48	(As above.)
7	119	56	30	21	11	7	226	44	
8	115	45	32	23	9	8	215	55	
9	130	55	28	17	8	5	230	40	
10	111	52	35	20	10	9	218	52	
Aver.	116	53	31	19	9	7	219	51	

20 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	182	47	13	5	3	0	247	23	
2	170	59	16	6	3	2	251	19	
3	173	53	18	9	5	4	253	17	
4	188	43	9	15	9	3	255	15	
5	165	55	17	8	5	4	245	25	
6	171	47	21	12	10	5	251	19	(As above.)
7	130	63	40	10	10	3	243	27	
8	185	48	15	3	3	2	251	19	
9	162	57	18	12	7	5	249	21	
10	177	60	14	6	5	2	257	13	
Aver.	170	53	18	9	6	3	250	20	

SIZE OF RINGS ON THE TARGET.

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36¾ "

} The area of each belt, between two rings, is the same as above.

Having now given full details as to the patterns, &c., we summarise them, with a statement of their respective killing circles:

VENA-CONTRACTA GUNS, WITH 1¼oz. CHARGES.

	Cylinder Barrel.			Choked Barrels.		
12-20 Bore:	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
Pattern	259	224	127	267	227	154
Killing circle	26in.	33in.	36in.	26in.	33in.	36in.
12-18 Bore:				(2 barrels)		
Pattern	—	—	—	253	221	163
Killing circle	—	—	—	28in.	33in.	36in.
12-16 Bore:				(2 barrels)		
Pattern	—	—	—	269	231	172
Killing circle	—	—	—	26in.	32in.	36in.

VENA-CONTRACTA GUNS, WITH 1oz. CHARGES.

12-20 Bore.	Cylinder Barrel.			Choked Barrels.		
Pattern	217	189	135	239	195	159
Killing circle	26in.	33in.	36in.	26in.	30in.	30in.
12-18 Bore:				(2 barrels)		
Pattern	—	—	—	235	197	141
Killing circle	—	—	—	24in.	32in.	36in.
12-16 Bore:				(2 barrels)		
Pattern	—	—	—	244	212	160
Killing circle	—	—	—	26in.	30in.	36in.

The following particulars relative to the shooting of the heavy 12-bore (weighing 7lb.), as well as the light guns of 12, 16, and 20 bores (none of which exceeded 6lb.), are quoted from the tables given on page 158.

HEAVY 12-BORE.

	Cylinder Barrel.			Choked Barrel.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
1¼oz. CHARGE:						
Pattern	258	185	115	296	250	168
Killing circle	30in.	36in.	36in.	22in.	33in.	36in.
1oz. CHARGE:						
Pattern	242	163	124	261	235	174
Killing circle	30in.	36in.	36in.	22in.	30in.	33in.

It is curious that this 12-bore gun gave rather higher patterns with the 1oz. charge at 40 yards, although it did not do so at the shorter ranges; and likewise that the 12-20 gun did the same.

The following are the average results of the light 12, 16, and 20-bore guns, copied from the tables on page 161:

LIGHT 12, 16, AND 20-BORES, WITH 1oz. CHARGES.

	Cylinder.			Slight Choke.			Fuller Choke.		
	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.	20yds.	30yds.	40yds.
Light 12-Bores (5 barrels):				(3 barrels)			(4 barrels)		
Pattern	2.0	168	106	230	186	130	229	203	152
Circle	30in.	35in.	35in.	30in.	32in.	35in.	25in.	31in.	35in.
16-Bores (4 barrels):				(3 barrels)			(5 barrels)		
Pattern	218	151	107	236	166	124	235	203	157
Circle	31in.	36in.	37in.	30in.	33in.	34in.	26in.	32in.	35in.
20-Bores (7 barrels):				(7 barrels)			(4 barrels)		
Pattern	221	155	100	236	184	125	249	214	149
Circle	32in.	35in.	35in.	27in.	33in.	35in.	25in.	31in.	35in.

The general conclusions which we draw from the foregoing records are that, taken on the whole, the results are very good, especially with the 12-18 bore. These trials have brought to light the fact that the original 12-20 bore is rather too small in gauge. The friction in the barrel necessitates the expenditure of an additional grain of powder, and even then the velocity is not quite so high as in the 12-18 or 12-16; and the patterns also are not so good as in Messrs Lang's modifications. Besides, in the 12-18 there are all the advantages of the Vena-Contracta system, viz., extreme lightness of the barrel forward and massive breech ends, thereby ensuring great safety, and a very handy weapon.

Ordinary wadding may be used in these guns with good results, but the best shooting is obtained with wadding as follows: Card over powder, ⅜in. felt, then the shot, and a card over the shot. There is no need for a greater amount of wadding than this, because the felt wad is compressed in the contracted part of the bore and by itself acts as a thoroughly effective gas check. We may also mention that, although upwards of 500 cartridges have been fired from these guns, not the slightest sign of leading in the barrel, or balling of the shot, has been perceived. P.—T.

A FORMER TRIAL OF SMALL-BORE AND 12-BORE GUNS.

(*Field*, Nov. 10, 1888; Vol. 72, p. 690.)

SOME warm discussions have arisen with respect to the relative merits of small-bores as compared with guns of 12-gauge; and although we have not thought that such experiments as have been carried out suffice to confirm the claims advanced by enthusiastic admirers of the "little toys," we must admit that, in good hands, remarkably satisfactory execution is done by these diminutive weapons, and we are not surprised that those with whom weight is an important consideration find themselves, at the end of a day's shooting, more comfortable in body and contented in mind than they would have been if they had been carrying gun and ammunition of more ponderous character.

We are of opinion that every man should choose, for his personal use, that kind of gun which he finds will give him the best practical results—quite irrespective of what may, on theoretical considerations, be held to be the most effective weapon. Nevertheless we hold that the fact of one or more individuals being able to shoot better with a particular gun does not prove that the gun itself is better than others of a different description. About a twelvemonth ago an ardent advocate of the "28" asserted that it was capable of beating the 12-bore. A trial of this gentleman's pet gun at the target showed that it shot very well for so small a weapon, but, when put into competition with a good 12-bore, it failed to maintain the character which had been claimed for it.

It was afterwards said that the trial which had been carried out was not of such a nature as would demonstrate the best characteristics of these small-bores, whose *forte* lay in their great killing powers with large shot at long ranges; and we were asked to carry out some further trials to test their merits in this respect. It was useless, for such a purpose, to test, as a champion of its class, an unknown gun, because, in the event of its defeat, it might easily be alleged that it was below mediocrity; and as we failed to obtain one which had already achieved a high character, the affair fell through for the time being.

Recently, however, another admirer of 28's proclaimed his belief that his gun was fully equal to the 12-bore in force, though with the smaller charge of shot it could not be expected to make as large a pattern; and he, too, especially relied on the killing power of his gun with No. 4 shot at long ranges. Being quite ready to be convinced by the "irresistible logic of facts," we requested this gentleman to lend us his gun for a few days, in order to have it tried in comparison with a 12-bore; and he most kindly complied with our request. It certainly is a very pretty little weapon. It was made by Mr. W. Ford, of Birmingham; its barrels weigh 2lb. 1oz., yet, being only 22in. long, are stout for their weight, and are bored for No. 28 "perfect" cases; the total weight of the gun is barely 4lb. 1 oz. As this so-called 28-bore is really of 24-gauge, we shall throughout this article call it a 24-bore, in order to distinguish it from a true 28-bore, bored for paper cases, which was tried at the same time.

We had received several letters asking us to try a real 28-bore in comparison with the *pseudo* 28, bored for brass cases, and we thought this a good opportunity of carrying out the suggestion, as we knew of a gun of very high character that would well meet our requirements. This gun belongs to the son of Mr. Brown, proprietor of the Nunhead shooting grounds—a young lad, whose wonderful skill in shooting has been previously alluded to in our columns, and who, with this 28, frequently "wipes the eye" of his seniors armed with pigeon guns. We accordingly requested Mr. Brown to lend us the little gun for the purpose of this trial, and he very courteously placed it at our service. It is, as already stated, a true 28-bore, but, although smaller in gauge, is not so light as the 24-bore, the barrels being five inches longer, viz., 27in., and their weight alone is 2lb. 7oz., while the full weight of the gun is 4lb. 14oz. It was made by W. W. Greener. The 12-bore with which these two little weapons were put into competition was made by Messrs. Cogswell and Harrison, has 30in. barrels, and weighs 7lb. In each instance, only the left or full-choke barrel was shot.

The loading adopted for the 24-bore and the 28-bore was the same as recommended by the owners of the respective guns—the former being 22grs of Schultze powder and 1oz. of shot, with a pink edged wad over the powder, then a grey felt and thin card, and another thin card over the shot; the latter also had 22grs. of Schultze, but only ¾oz. of shot, and the wads were a thin black card over powder, followed by a thick felt, and a pink-edge wad over the shot. The 12-bore was loaded with 42grs. of Schultze and 1¼oz. shot, and the ordinary Field wads.

The main purpose of the trial was to test No. 4 shot at long ranges; but, in order to give a line of comparison with ordinary trials, we had a supply of cartridges for each gun loaded with No. 6 shot as well as No. 4 (other conditions being the same), and

the guns were fired at 40 yards range as well as 60 and 80 yards. We resolved, also, that the issue of the contest should not depend solely on patterns and force-gauge records, and so we asked Messrs. Cogswell and Harrison to allow us to carry out the trial on their range at Harrow, where we should have the advantage of using their chronograph, as well as their card-rack test, of which we gave a description in the *Field* of Sept. 1, 1888. We could not use all three kinds of apparatus at the long distances, because the chronograph and force-gauge were fixtures in connection with the 40 yards range; consequently for 60 and 80 yards the card-rack was alone used as the test of penetration.

In the first instance, we will give a short table, showing the performance of the three guns with No. 6 shot at 40 yards. The pattern made by each in the ordinary 30in. circle is stated in the first column of figures; next comes the force per pellet registered on Mr Walsh's force-gauge; and the third column shows the mean velocity of the shot throughout the 40 yards range, as taken by the chronograph. As the chronograph is simply a recorder of the time taken by the shot in traversing the stated distance, and does not show the actual velocity either at the muzzle or the end of the range, we have calculated the final or striking velocity of the pellets, at the end of the 40 yards, from the records made by the force-gauge, and have placed these figures in the fourth column; and, as we thought that some readers might like also to see a statement of the relative amount of energy left in the pellets when they struck the target, we have given, in the last column, the amount in foot-pounds, as calculated from the final velocities given in the column preceding:

FORTY YARDS RANGE.—No. 6 SHOT.

	Pattern.	Force.	Mean Velocity.	Final Velocity.	Energy per pellet.
12-bore (30-inch)...	216	2·05	861 ft.sec....	553 ft.sec....	1·10 ft.lb.
24-bore (22-inch)...	185	1·68	698 „ ...	454 „ ...	0·74 „
28-bore (27-inch)...	138	1·82	726 „ ...	491 „ ...	0·87 „

As might be anticipated, with the difference in quantities of shot used, the larger the charge the larger the pattern. But when allowance is made for the variation of weight, there is not much difference in the proportionate pattern; for the 12-bore put 71 per cent. of its pellets in the 3in. circle, the 24-bore put in 69 per cent., and the 28-bore 68 per cent. The force and velocity also varied in accordance with the proportion of the powder used; but we shall have more to remark on this part of the subject after giving an account of the shooting at the longer ranges.

Now we will proceed to the experiments with No. 4 shot at 40 yards, giving the results in the same form as with No. 6 stated above.

FORTY YARDS RANGE.—No. 4 SHOT.

	Pattern.	Force.	Mean Velocity.	Final Velocity.	Energy per pellet.
12-bore (30-inch)...	132	3·35	878 ft.sec....	596 ft.sec....	1·95 ft.lb.
24-bore (22-inch)...	113	3·02	740 „ ...	538 „ ...	1··9 „
28-bore (27-inch)...	96	3·11	786 „ ...	541 „ ...	1·68 „

With No. 4 shot, the 12-bore put 66 per cent. of its charge in the 30in. circle; the 24-bore put in 64 per cent.; and the 28-bore 72 per cent. So that the first two guns did not do quite so well with large shot at 40 yards, whereas the smallest of the three did better.

At the longer ranges, for the reason already stated, the guns were not tried at the regular target, but the penetration was taken by Messrs. Cogswell and Harrison's card-rack; and, instead of the patterns being taken in the ordinary 30in. circle, temporary targets had to be put up, and these were 27in. square. The area of the 30in. circle is 707 sq. in., and that of the 27in. quadrangle is 729 sq. in.; so the disadvantage in shape is compensated for by increased area, and the proportion of the charge thrown upon the target may be taken as about the same.

The penetration on the card-rack is recorded in two ways, viz., according to the number of cards perforated by three pellets, and the number of cards perforated by only one pellet. Where there are fractions, it is due to the numbers representing averages. When three successive shots were fired and gave practically the same results, they were taken to form the average; but where there were any material differences, the number of shots was extended to six, and the average taken of the whole. The results of the shooting of the three guns at 40, 60, and 80 yards were as follows:

RECORDS AT CARD-RACK, &c.

	No. 6 Shot. Pattern.	Penetration by Three Pellets.	Penetration by One Pellet.	No. 4 Shot. Pattern.	Penetration by Three Pellets.	Penetration by One Pellet.
Forty Yards:						
12-bore	216	20	22	132	27	29
24-bore	185	14½	16½	113	21	23
28-bore	138	17	17½	96	23	25½
Sixty Yards:						
12-bore	103	11½	17½	88	21	24
24-bore	90	8	9	77	15	16½
28-bore	80	9½	11	45	14	18
Eighty Yards:						
12-bore	54	7	8½	39	14½	15½
24-bore	49	3½	5	39	9½	11½
28-bore	40	6	7½	22	7	12

It will be observed that at every distance, with both sizes of shot—whether demonstrated by the force-gauge, the chronograph, or the card-rack—the penetration was greater with the 12-bore than with the smaller guns. From our point of view we scarcely could see how any other result was to be anticipated, because the proportion of shot to powder is so much greater with the small-bores than it is with the 12-bore. Let us look at the difference of proportion in the different guns, and compare results.

	Powder.	Shot.	Proportion.
12-bore	42 grains	492 grains	1 to 12
24-bore	22 „	437½ „	1 to 20
28-bore	22 „	328 „	1 to 15

(Of course, with black powder, which is double as heavy as the nitro-compound, the corresponding proportions would have been—12-bore, 1 to 6; 24-bore, 1 to 10; and 28-bore, 1 to 7½.)

Now it certainly would have surprised us if this 24-bore, at any distance, had shown as great penetration as the 12-bore, because the little gun was shooting an ounce of shot with 22grs. of powder, and the proportionate charge of powder with 1⅛oz. of shot would be only 25grs., whereas the 12-bore really uses 42grs. No one would expect a 12-bore to show very much penetration with 25grs. and 1⅛oz.; and, although more force is developed in a narrow gauge than in a wide one from the same quantity of powder, it has always appeared to us that the "little toys" were too heavily handicapped when called upon to compete under so great a disadvantage.

When Mr. Bellairs' gun (which, like the above, was a 24-bore using No. 28 "perfect" cases) was tested, last winter, it was tried with three different charges of powder, viz., 32grs., 28grs., and 22grs. Mr. Bellairs had said that his usual charge was 32grs., with 1oz. of No. 6; on examining the loaded cartridges he sent with the gun, it was found that they contained only 28grs., and the gun was accordingly tested with both charges, in order to see which would give the best results. As many persons use only 22grs. in these small bores, that charge was likewise tested, as a matter of curiosity, and, if the results had been more favourable than the others, they would have been printed; but, the reverse being the case, we thought it was not fair to publish the trial with a charge which the owner of the gun never professed to use. After the trial, however, a suggestion was made that the gun was overloaded, and would probably have done better with less powder; and therefore, as we are now publishing the records of another gun of the same gauge as that belonging to Mr. Bellairs, we take the liberty of adding the particulars relative to his gun, in order to show what really was the result of using a smaller charge of powder. Mr. Bellairs' gun was tried with E.C. as well as Schultze, and the amount of force registered by each, with the respective charges, was as follows:

Charge.	E.C. Powder. Force.	Schultze Powder Force.
32 grains	1·56	1·71
28 grains	1·69	1·65
22 grains	1·45	1·42

The pattern increased with the diminution of the powder charge, but the "figure of merit," derived by adding pattern to penetration, was not equal to that shown by 28 grains.

But, to return to the trial of last week, Mr. Brown's little 28, with the same quantity of powder as the 24-bore, but one-fourth less shot, naturally showed more penetration, with a reduced pattern. The remarkable shooting of this little gun has been a surprise to us, as we have no doubt it will also be to many of our readers; and, in the hands of one who has so extraordinary an aptitude for "getting on" his birds as Master Charles Brown, one can readily understand the great amount of execution that is done by so small a weapon.

As most people will admit, a good deal of the *kudos* that is bestowed on guns is dependent in great measure upon the men behind them; and we expect that, in various instances, where small-bore enthusiasts, such as "20,000 Shots," W. L. C., Mr. Bellairs, and others, have depicted the performances of their favourites in a rather *couleur de rose* tint, they have modestly bestowed on the gun the full credit for performances in which they themselves were certainly not nonentities; and, consequently, when less-gifted individuals have attempted to use the same kind of gun, they (with an equal disregard of their own share in the transaction) have rather ungraciously proclaimed the weapon "a fraud." Hence we probably may account for the differences of opinion: there are two sides to the shield. P.—T.

OTHER TRIALS OF 12, 16, AND 20-BORE GUNS.

(*Field*, Sept. 17, 1892; Vol. 80, p. 443.)

QUESTIONS have arisen, from time to time, as to what bore is best for those who wish to use guns of light weight; and enthusiastic lovers of small-bores have occasionally proclaimed that their pets (or "popguns" as detractors derisively call them) are capable of doing as much execution on game as more ponderous weapons used with much heavier charges of powder and shot. Various trials which have been carried out, with chronograph, with force-gauge, and with paper pads, to test the accuracy of such assertions, have failed to demonstrate the correctness of the statements. But when the little guns have been beaten, they have not been disgraced: the fault has not lain with them, but rather with those who, actuated by *trop de zèle*, have demanded results which were practically incapable of attainment by the means at their disposal. If competitions are to be made for pattern, one could hardly suppose that 1oz. of shot would give as large numerical results as 1¼oz.; and, in like manner, if the charge of powder in one gun has to propel a charge of shot of eight or ten times its own weight, it is too much to expect that the velocity imparted would be as high as when the shot is only five or six times the weight of the powder. Yet attempts have been made to show that the little weapons can perform feats of this kind; and blame can scarcely be attached to the guns for want of success under such conditions.

There is another mode of comparison, however, in which small-bores exhibit themselves with much better effect, and that is when a question of this kind is asked: Given a gun of a certain weight, and a charge limited to so much powder and so much shot, what size of bore is likely to produce the highest record?

Definite information on this point is difficult to obtain. The *Field* Gun Trial of 12, 16, and 20 Bores, in 1879, showed that guns of small gauge were capable of showing excellent results; and many owners of small-bores are greatly pleased with the little weapons they are in the habit of using; yet the gist of the matter, when the subject is discussed, has generally resolved itself into the fact that certain gun-makers have a special faculty for turning out good small-bores; but as regards the influence of the bore itself, independent of the special skill of the maker of the gun, information is practically *nil*.

In the spring of 1892 we arranged to carry out a few experiments for the purpose of ascertaining how guns of 12, 16, and 20-bores, of about equal weight, would behave when tested with equal charges of powder and shot. We did not then try them for pattern, as that is so much dependent on skill in the boring; but we tested them for muzzle velocity, recoil, and strain in the barrel. A light gun of 5½lb. weight, with 28in. barrels, was chosen to do battle for the 12-gauge: and before putting it into competition with guns of smaller bore, we tried it against a 7lb. 12-bore with 30in. barrels, to see whether they differed much in their performances. Of course, as the 7lb. gun was one-third heavier than that of 5½lb. weight, it was to be expected that the energy of recoil of the light gun would be about one-third more than that of the heavy gun. The cartridges contained the customary 12-bore charge of 3drs. of black powder, or 42grs. of nitro, with 1⅛oz. of No. 6 shot, and "Field" loading. In addition to the ordinary No. 4 (C. & H. T.S.) we tried No. 4 diamond grain, but unfortunately overlooked the last-named powder in the light gun until after we had returned the latter to its owner. The results (placed in order of velocity of the respective rounds) were as follows:

3DRS. OF POWDER AND 1⅛OZ. OF NO. 6 SHOT.

		No. 4 BLACK (C. & H. T.S.)				Averages.
Heavy 12-bore...	Velocity...	1185	1205	1227	1237	1237 = 1218 ft.sec.
	Recoil	*33·3*	*32·8*	*32·8*	*32·8*	*33·0 = 32·9 ft.lb.*
Light 12-bore...	Velocity...	1171	1174	1189	1240	1243 = 1204 ft.sec.
	Recoil	*44·4*	*45·3*	*45·3*	*45·3*	*45·3 = 45·1 ft.lb.*

		No. 4 DIAMOND GRAIN.				Averages.
Heavy 12-bore...	Velocity...	1205	1214	1221	1236	1240 = 1221 ft.sec.
	Recoil	*33·8*	*34·0*	*34·0*	*33·9*	*34·0 = 33·9 ft.lb.*

SCHULTZE.

Heavy 12-bore...	Velocity...	1192	1199	1205	1221	1221 = 1208 ft.sec.
	Recoil	*25·4*	*25·8*	*25·5*	*25·8*	*26·0 = 25·7 ft.lb.*
Light 12-bore...	Velocity...	1162	1205	1205	1208	1218 = 1200 ft.sec.
	Recoil	*33·3*	*34·7*	*35·3*	*36·9*	*36·3 = 35·3 ft.lb.*

On comparing these records it will be seen that there was not much difference between the *average* velocities (for 5 yards range) with the respective powders and weapons; but the heavy gun shot more regularly than the light one. The difference between the highest and lowest rounds fired from the 5½lb. gun was always wider than in the case of the 7lb. gun; *e.g.*, with No. 4 T.S. the difference was 52 with the heavy, and 72 with the light gun; with Schultze it was 29 with the heavy and 56 with the light. Diamond No. 4 gave a little higher velocity, with more regularity, than the ordinary No. 4; and, though there was a slight increase of recoil, the rounds were remarkably even.

In the next trial, of three sizes of bore, the charge of powder and shot was uniform throughout; but certain differences had to be made in the wads, in order to accommodate the charge to the cartridge case. With the light 12-bore we used two methods of loading—the first was the usual "Field" loading, except that two ⅜in. felts were used instead of one, in order to fill out the case; and in the second a 12-gauge card was substituted for the 11½ "Field" wad, and there was consequently a little more turnover. In the 16-bore there was a card over the powder, and only one ⅜in. wad; and in the 20-bore it was requisite to reduce the felt to ¼in., in order to get the charge into the case. The 16-bore gun weighed 5lb. 6½oz., and had 28in. barrels; the 20-bore also weighed 5lb. 6½oz., and had 29in. barrels. As the extra 2½oz. in the weight of these guns would place the light 12-bore at a little disadvantage in the records of recoil, we have proportionately altered them, so as to represent the three guns as if of equal weight, viz., 5½lb. each. The results obtained with the three varieties of powder were as follows:

2¼DRS. OF POWDER AND 1OZ. OF NO. 6 SHOT.

No. 4 BLACK (C. & H. T.S.)

Light 12-bore ("Field" wad)	Velocity...	1157	1174	1177	1177	1186 = 1174 ft.sec.
	Recoil	*34·0*	*35·6*	*34·9*	*34·9*	*34·9 = 34·9 ft.lb.*
Light 12-bore (card wad) ...	Velocity...	1136	1157	1183	1294	1237 = 1187 ft.sec.
	Recoil	*34·0*	*34·0*	*34·1*	*34·7*	*36·6 = 34·1 ft.lb.*
16-bore.....	Velocity...	1205	1208	1211	1214	1237 = 1215 ft.sec.
	Recoil	*32·0*	*32·0*	*32·7*	*32·1*	*32·0 = 32·2 ft.lb.*
20-bore.....	Velocity...	1224	1240	1254	1271	1281 = 1254 ft.sec.
	Recoil	*32·3*	*32·3*	*32·0*	*32·3*	*32·8 = 32·4 ft.lb.*

No. 4 DIAMOND GRAIN.

Light 12-bore ..	Velocity...	1205	1214	1214	1219	1234 = 1217 ft.sec.
	Recoil	*36·0*	*35·3*	*35·3*	*35·7*	*36·0 = 35·7 ft.lb.*
16-bore.....	Velocity...	1214	1222	1224	1234	1234 = 1226 ft.sec.
	Recoil	*33·6*	*33·6*	*33·3*	*34·4*	*34·4 = 33·9 ft.lb.*
20-bore.....	Velocity...	1263	1267	1288	1291	1300 = 1282 ft.sec.
	Recoil	*35·7*	*36·7*	*36·5*	*36·7*	*36·7 = 36·4 ft.lb.*

SCHULTZE.

Light 12-bore ("Field" wad)	Velocity...	1082	1094	1107	1117	1122 = 1105 ft.sec.
	Recoil	*25·2*	*25·3*	*26·0*	*26·3*	*26·9 = 25·9 ft.lb.*
Light 12-bore (card wad) ...	Velocity...	1070	1072	1090	1133	1136 = 1100 ft.sec.
	Recoil	*23·6*	*24·4*	*24·0*	*24·0*	*24·7 = 24·1 ft.lb.*
16-bore.....	Velocity...	1246	1251	1254	1254	1261 = 1253 ft.sec.
	Recoil	*28·7*	*26·7*	*28·0*	*28·0*	*28·7 = 28·0 ft.lb.*
20-bore.....	Velocity...	1195	1218	1227	1271	1288 = 1240 ft.sec.
	Recoil	*26·7*	*28·0*	*28·3*	*28·1*	*27·3 = 27·9 ft.lb.*

In all instances the light 12-bore was beaten by the guns of smaller gauge; and in most instances the 20-bore showed higher velocity than the 16-bore. Another curious fact is, that the 12-bore, although giving less velocity than the smaller gauges, exhibited a greater amount of recoil (even after making allowance for weight of gun as already mentioned). Occasionally (as with diamond grain powder in the 20-bore gun) the recoil was highest with the smallest bore; but that arose from the great increase of velocity imparted to the shot. Had the recoil of the 20-bore, with 1282 f.s. velocity, been in proportion to that of the 12-bore, with 1217 f.s., the record of the former would have been 40·1 ft.lb., instead of 36·4 ft.lb., as given above. It seems not improbable that a portion of this difference may be due to the fact that the column of air that has to be expelled from the 20-bore is smaller in area than that in the 12-bore, and consequently less in weight; also, when the outrush of gas occurs,

the pressure on the base of gun is greater, as the area of the 12-bore is 40 per cent. greater than that of the 20-bore.

With the nitro the effect was more marked than with black powder, as the weight of shot was insufficient to bring out the force of the powder in the 12-bore. Judging merely by the proportion of powder and shot, the velocity of the 1oz. charge ought to have been nearly the same as the velocity of the 1⅛oz. charge previously fired from the same gun (the light 12-bore); but the actual record was about 100 f.s. less. And, with regard to the recoil, judging by the difference in velocity, the record ought to have been about 32 ft.lb. instead of only 28 ft.lb.

As to the difference in the wads used in the light 12-bore, it will be seen that the card wad, with increased turnover, gave a slight increase in average velocity; but there was a great difference in the regularity of shooting. With the "Field" wad the velocities varied from 1157 to 1174—a difference of 29; with the card and greater turnover the variation was from 1136 to 1237—a difference of 101. Similar differences, but not to so wide an extent, occurred with the nitro powder. It will also be observed that the shooting of the 20-bore was always less regular than that of the 16-bore.

An explanation of the cause of the increased velocity imparted to the shot by the small-bores may be found in the greater amount of force exhibited by powder when the diameter of the bore is reduced. In the next table we lay before our readers the results of some crusher-gauge experiments in the three calibres mentioned above; and in order to show the amount of strain to which the guns are submitted when tested in the proof-house, and to enable comparison to be made with that which they may undergo when ordinary service charges of sporting powders are afterwards employed in the same barrels, we give some records recently made. The records were taken at three plugs—the first 1in. from breech, the second at 2½in., and the third at 6in. Three rounds were fired of each charge, and each round gave three records—one at each plug. The following are the results, in tons per square inch:

12-Bore.				16-Bore.				20-Bore.			
Proof Powder, 6¼drs., and 1⅛oz. of shot.				Proof Powder, 5½drs., and 1⅛oz. of shot.				Proof Powder, 5drs., and 1⅛oz. of shot.			
Plug.	Tons.		Aver.	Plug.	Tons.		Aver.	Plug.	Tons.		Aver.
1st	4·44	4·52	4·58=4·51	1st	4·50	4·74	4·92=4·72	1st	5·70	5·78	5·81=5·76
2nd	4·12	4·41	4·44=4·32	2nd	4·41	4·44	4·71=4·55	2nd	5·54	5·57	5·52=5·54
3rd	3·24	3·43	3·54=3·40	3rd	3·67	3·84	3·87=3·79	3rd	4·15	4·24	4·30=4·23
No. 4 T.S., 3drs., and 1⅛oz. shot.				No. 4 T.S., 2¾drs., with 1oz. shot.				No. 4 T.S., 2½drs., and ⅞oz. shot.			
1st	2·50	2·55	2·74=2·60	1st	3·84	3·97	4·09=3·97	1st	3·54	3·64	3·77=3·65
2nd	2·18	2·29	2·12=2·20	2nd	2·34	2·60	2·88=2·59	2nd	2·45	2·79	3·12=2·79
3rd	1·50	1·50	1·58=1·53	3rd	1·24	1·32	1·41=1·32	3rd	1·12	1·32	1·41=1·28
No. 4 Diamond, 3drs., and 1⅛oz. shot.				Not taken.				Not taken.			
1st	3·90	3·97	4·12=3·66	—	—	—		—	—	—	
2nd	3·08	2·96	3·08=3·04	—	—	—		—	—	—	
3rd	0·87	0·87	1·12=0·95	—	—	—		—	—	—	
Schultze, 42grs., and 1⅛oz. shot.				Schultze, 38grs., and 1oz. shot.				Schultze, 34grs., and ⅞oz. shot.			
1st	2·50	2·74	2·96=2·73	1st	3·28	3·87	3·90=3·68	1st	3·46	3·61	3·98=3·67
2nd	2·29	2·45	2·74=2·49	2nd	3·16	3·61	3·67=3·48	2nd	3·20	3·43	3·90=3·51
3rd	1·12	1·12	1·12=1·12	3rd	0·87	1·12	1·58=1·19	3rd	1·22	1·32	1·58=1·37
E.C., 42grs., and 1⅛oz.				E.C., 38grs., and 1oz.				E.C., 34grs., and ⅞oz.			
1st	2·34	2·34	2·45=2·38	1st	3·74	3·97	4·30=4·00	1st	3·64	4·24	4·30=4·06
2nd	1·94	2·00	1·22=2·02	2nd	3·28	3·39	3·43=3·37	2nd	3·04	3·84	4·03=3·64
3rd	1·12	1·22	1·41=1·25	3rd	1·32	1·32	1·32=1·32	3rd	1·12	1·50	1·66=1·43
S.S., 42grs., and 1⅛oz.				S.S., 38grs., and 1oz.				S.S., 34grs., and ⅞oz.			
1st	2·40	2·45	2·55=2·47	1st	3·32	3·46	3·54=3·44	1st	4·85	5·07	5·18=5·03
2nd	1·80	1·87	2·18=1·95	2nd	3·04	3·36	3·46=3·29	2nd	2·45	4·24	4·58=3·76
3rd	1·32	1·32	1·32=1·32	3rd	1·41	1·58	1·80=1·60	3rd	1·32	1·50	1·94=1·59

In the above experiments we have not limited the charge to the one uniform standard of 2½drs. and 1oz., but thought it would be more useful to ascertain the strain with charges that are generally used in the respective bores.

It will be seen that, although the charge is decreased in the 16-bore, as compared with the 12-bore, there is a considerable increase in the strain; and, although there is a further decrease in the charge with the 20-bore, the strain is again increased with some powders, although not invariably so.

With the 20-bore charge used in the first-mentioned experiments, the strain would doubtless be considerably higher than here stated, because there was ½oz. more shot. In some 20-bore guns, as much as 3drs. of powder and 1oz. shot are used; and we know of one instance where such a gun, loaded with nitro powder, burst with very disastrous results. Looking at the above records, such a circumstance does not seem very surprising; for so heavy a charge in the narrow bore would greatly intensify the strain, which, not improbably, might considerably exceed that of the proof-charge.

It appears obvious, therefore, that those who wish to take advantage of the increased velocity resulting from the use of a smaller bore, should increase rather than diminish the weight of their guns, by putting in more metal at the breech. P.—T.

EXPERIMENTS WITH HARD AND SOFT SHOT.

(*Field*, Feb. 6, 1892; Vol. 79, p. 164.)

Practical demonstration is far preferable to ingenious speculation, whenever it can be applied to the settlement of questions in dispute; and, as differences of opinion often arise with reference to the relative amount of danger resulting from the use of hard and soft shot, we resolved to carry out some experiments for the purpose of ascertaining more clearly what the facts of the case really are.

Looking at the subject from a merely theoretical point of view, our predilections would be in favour of soft shot. The unhardened metal has greater specific gravity than chilled shot, and therefore would be less retarded by the atmosphere; consequently, other things being equal, it should strike the game with a larger amount of force. Moreover, its softness gives greater opportunity for the full expenditure of its force upon the body struck, so that it would be less likely to drill a hole through, and pass away with a portion of its power unexhausted; and the greater shock thus given to the animal hit would add to the chance of its being brought to bag.

Another side of the question, however, is this—that if the soft metal is more likely to be altered in form on striking the game, it would also be more easily knocked out of shape before arriving at its destination, and therefore be less likely to travel straight. The combustion of the powder produces an enormous pressure on the shot, and many of the pellets get more or less crushed before they leave the barrel of the gun; while others may be deflected by striking against objects *en route*. The distorted pellets may either describe moderate curves, like the biassed balls on a bowling green, or take much more erratic courses, according to the irregularity of the shapes into which they may be squeezed. Such pellets are not at all likely to strike the object fired at, but may not improbably hit something else that is far wide of the mark.

From what one hears and reads nowadays, it might be inferred that modern risks in shooting are much worse than were those of former times; and, with the greater number of guns, and the vastly increased facilities for loading and firing them rapidly, there necessarily must be an increase in the number of dangerous pellets flying at large. *Per contra*, there is less risk to the handler of the gun than there was in the old muzzle-loading days; but whether personal immunity in this respect renders people less considerate of danger to others than their forefathers were, is a matter upon which opinions may possibly differ. Certain it is that there was no scarcity of dangerous men in former days, any more than there is now—men devoid of self-control, who, whenever they catch sight of a bird or rabbit, blaze away without taking any consideration of where the shot may go. Then, as now, too, there were jealous shooters, who like nothing to escape them, and who do not affect even to plead the excitement of the moment as an excuse for bring danger upon others. As showing that this genus is by no means a new one, we give a quotation from an article on "Accidents with the Gun," published in the *Field* nearly forty years ago. After speaking in scathing terms of the man who "constantly places the existence of others in jeopardy through a want of that command over himself which every person ought to have acquired before he takes a gun in hand," the article in the *Field* of Jan. 30, 1858, proceeds:

> Those who pretend to labour under no excitement, and who coolly, deliberately, and wilfully shoot at game within a few inches of their fellow creatures, relying on their superior skill, deserve still severer reprobation than the semi-sane man who cannot control himself. We should not venture to express ourselves thus forcibly, if accidents of a serious nature, in addition to loss of life, which arose from this particular cause, had not come within our own immediate knowledge, during a long and extensive experience. If any sportsman wishes to ascertain practically the risk which is incurred by shooting near others, even with the best of guns, let him observe the effect of some half-dozen shots fired on the smooth surface of a piece of water on a fine calm day; and, if he makes good use of his eyesight, he will discover, every now and then, however closely and accurately the gun may carry, one or two outside pellets striking very wide of the main charge; and these stray pellets are the means by which keepers are sometimes deprived of their eyesight, when reckless and inconsiderate sportsmen cannot refrain from taking a hazardous shot. The width at which a few pellets will occasionally diverge from the main charge, and the very great distance at which the strongest shot in the charge will do execution, being well-known and admitted facts, ought to have great influence with all sportsmen in preventing them from shooting in the direction of their fellow creatures, when the slightest doubt exists in their

minds. Many years ago a gentleman was killed from an immense distance by one single shot hitting him in the eye. He survived the accident about three minutes.

Besides this fatality, we came across several other accidents, of a more or less serious character, recorded in old numbers of the *Field*, from the year 1853 onwards; and we here briefly summarise them, in order to show their nature:

Some gentlemen were out grouse shooting in Yorkshire, and one of the party was struck in the face by several stray pellets, one of which lodged in the pupil of his left eye.

At a rabbit-shooting party a man was struck by a pellet which, it was feared, had also destroyed the sight of one eye.

At another rabbit-shooting party one of the men was struck in the eye by a pellet which was supposed to have glanced off some gravel. Having lost the sight of that eye, he brought an action against the firer of the shot: but the judge who tried the case decided that it was accidental, and added that, "as danger always accompanied such sports, people should go out prepared."

A farm labourer at work was struck in the eye by a pellet from the gun of a sportsman who came rabbit shooting in the same field; the injured man brought an action, and recovered £50 damages.

The Emperor Napoleon III. was struck in the nape of the neck by pellets said to have come from the gun of the Duke of Magenta, but the injuries were not serious.

A gamekeeper died from the effects of being struck in the face by several pellets from his master's gun. It was said that the charge must have glanced off something hard, as the man was standing 25 yards to the right of the gun.

A military officer of high rank was struck in the eye by a pellet from the gun of a clergyman; and it was feared that the sight was destroyed.

A young man was hit in the face by three pellets from the gun of a friend. One of them entered the brain, and proved fatal almost immediately.

The last case that we shall quote was given with much fuller detail than any of the others, and was accompanied by an illustration, which we reproduce. The writer said:

My friends were rabbit shooting. The ground was rough, covered with brushwood, stones, and creeping plants. They were posted on a bank, and formed an arc of a circle, the extremities of which were 40 yards apart, facing high ground, from which the rabbits were driven by ferrets. The position of the party will be better understood by the following sketch of the ground:

A rabbit bolted opposite to A., who fired (in the direction shown by the arrow), breaking the rabbit's hind leg; the shot (No. 8) glanced from a stone and wounded more or less the rest of the party B., C., D., E., F., while lookers-on standing between them were untouched. B. was struck by three pellets, which must have glanced at right angles; one of the shot

entered the skin over the nose and nearly penetrated the eye, another entered the hand, and the third his leg. C. received a smarting shot in the hand. D. was hit on the forehead by a fragment of the stone (which was broken to atoms). A shot entered above the eyebrow of E., and travelled an inch below the skin. F., who was most seriously hurt, although most distant, was struck by two pellets, one penetrating the groin.

It may be inferred either that the stone struck by the charge must have had a very irregular surface, with angles in various directions, to scatter the shot far and wide in this fashion; or else that the pellets were so greatly distorted by contact with the stone, that they flew about in a most erratic manner. And (if the drawing of the sketch be correct) the rabbit must have been pretty close to the gun, seeing that the arc of the circle from A. to F. was only 40 yards, and the distance from A. to the rabbit is less than a dozen yards.

All the above-mentioned accidents occurred years before chilled shot came into use; and we desired now to ascertain whether the modern shot gave different results—if so, whether the change was for the worse or the better. Shooting over water, however, as recommended in the first extract, is but an uncertain kind of evidence. It may suffice to convince the person who tries the experiment, but affords little definite information that he can impart to others. And as we wished to obtain explicit particulars that we could lay before our readers, we had to adopt a different course.

In order to secure means for making exact measurements, we had recourse to an unusually large target. At this target a great many rounds were fired from a distance of 28 yards, and the measurement of the spread of the pellets was taken after every round. Both hard and soft shot were tried, from three guns—one a choke-bore, another with the ordinary "cylinder" boring, and the third a cylinder which had a rather abrupt cone at the end of the cartridge chamber. Formerly such guns as are last mentioned were much more numerous than they are at present; but many are still in use, and some (generally low-priced guns) are even now thus made. We had found, in previous experiments, that these abrupt cones damaged the shot considerably, and we now proceeded to ascertain to what extent they increased the straggling of the pellets. We may add that the cone in the gun here used was not so abrupt as in many others we have seen; so the probability is that there are some guns in use which will scatter pellets abroad more wildly even than this one.

Besides the two kinds of shot, we used two kinds of powder—No. 2 black and Schultze. Between No. 4 and Schultze the difference would be too small to be of much importance, though No. 4 would probably give rather the wider spread. With No. 2, however, the greater rapidity in combustion of the powder would be more likely to crush the pellets out of shape, and we accordingly gave that a separate trial. Six rounds of each kind of powder and shot were fired, from each of the three guns; and, for facility of comparison, we have printed the rounds, not in the order of firing, but have arranged them progressively, according to the respective measurements.

NITRO POWDER.

HARD SHOT.

CHOKE-BORE GUN:

2 pellets	outside	3½ft. circle.
4 "	"	3¾ft. "
7 "	"	3¾ft. "
2 "	"	4ft. "
2 "	"	4ft. "
1 "	"	5¾ft. "

CYLINDER GUN:

2 pellets	outside	5ft. circle.
1 "	"	5ft. "
2 "	"	5ft. "
2 "	"	5ft. "
4 "	"	5ft. "
4 "	"	5½ft. "

CYLINDER WITH ABRUPT CONE:

3 pellets	outside	6ft. circle.
3 "	"	6ft. "
7 "	"	6ft. "
1 "	"	7ft. "
5 "	"	7ft. "

A string of pellets left the main body; some outside 12ft. circle.

SOFT SHOT.

CHOKE-BORE GUN:

5 pellets	outside	3½ft. circle.
1 "	"	4ft. "
2 "	"	4ft. "
3 "	"	4ft. "
1 "	"	8ft. "
2 "	"	8ft. "

CYLINDER GUN:

9 pellets	outside	4ft. circle.
3 "	"	4½ft. "
3 "	"	5ft. "
1 "	"	6ft. "

A string of pellets left the main body; some outside 9ft. circle. Ditto; some outside 11ft. circle.

CYLINDER WITH ABRUPT CONE:

4 pellets	outside	6ft. circle.
8 "	"	6ft. "
11 "	"	6ft. "
12 "	"	7ft. "
11 "	"	8ft. "
3 "	"	10ft. "

From the above measurements (taken at 28 yards from the gun) it will be seen that, with the chokebore, the outside pellets of soft shot had more than 2ft. wider spread than those of hard shot; and, of course, with longer distances, the divergence would naturally become greater.

With the cylinder gun, the widest spread with hard shot was 5½ft. But soft shot gave double the divergence of hard shot.

The gun which had an abrupt cone generally gave a wider scattering than either of the other two guns, whichever kind of shot was used; but its maximum divergence was shown with hard shot, a string of which extended beyond a 12ft. circle.

With No. 2 black powder there was a general increase in the spread, as will be seen by reference to the following tables:

BLACK POWDER.

HARD SHOT.

CHOKE-BORE GUN:

2 pellets	outside	4ft. circle.
3 "	"	4½ft. "
1 "	"	5½ft. "
1 "	"	5½ft. "
1 "	"	5½ft. "
1 "	"	8ft. "

CYLINDER GUN:

1 pellet	outside	6ft. circle.
1 "	"	6ft. "
1 "	"	7ft. "
1 "	"	8ft. "
1 "	"	8ft. "
1 "	"	8ft. "

CYLINDER WITH ABRUPT CONE:

4 pellets	outside	8ft. circle.
11 "	"	8ft. "
12 "	"	8ft. "
3 "	"	9ft. "
7 "	"	12ft. "
1 "	"	15ft. "

SOFT SHOT.

CHOKE-BORE GUN:

1 pellet	outside	5ft. circle.
1 "	"	5ft. "
2 "	"	6ft. "
1 "	"	7ft. "
3 "	"	12ft. "

A string of pellets left the main body; 10 were outside 10ft. circle; 9 outside 14ft.; and 1 outside 16ft.

CYLINDER GUN:

1 pellet	outside	6ft. circle.
1 "	"	7ft. "
1 "	"	10ft. "
Cluster of 9 "		10ft. "
1 pellet	"	12ft. "
5 "	"	12ft. "

CYLINDER WITH ABRUPT CONE:

9 pellets	outside	9ft. circle.
7 "	"	10ft. "
12 "	"	10ft. "
13 "	"	10ft. "
7 "	"	10½ft. "
11 "	"	13ft. "

With No. 2 black powder there was always more scatter than with the nitro-compound; and the chokebore showed a marked increase when soft shot was used. With the cylinder gun the soft shot also gave a wider spread, though the proportion of increase was less than with the choke. The worst scatterer, as a general rule, was again the gun with abrupt cone; and its maximum divergence again occurred with a hard pellet.

It is not easy, however, to comprehend at a glance the relative importance of the above statistics, and we accordingly give a summary, stating only the totals; and it should be borne in mind that, as these experiments were carried out at a distance of 28 yards, the divergency of the pellets at 40 yards would be nearly one-half greater; so that what represents a 16ft. circle in the following diagram (Fig. 1) would represent a circle of 25ft. at 40 yards, and about 30ft. at 50 yards.

First, we give the results of the two kinds of powder, and two kinds of shot, when fired from a choke-bore gun:

Choke-bore Gun. Straggling pellets:	Schultze Powder. Hard shot.	Schultze Powder. Soft shot.	No. 2 Black. Hard shot.	No. 2 Black. Soft shot.
Between 4ft. and 6ft. circles	5	6	8	unknown
„ 6 „ 8ft. „	0	0	1	3
„ 8 „ 10ft. „	0	3	1	0
„ 10 „ 14ft. „	0	0	0	13 (8)
„ 14 „ 16ft. „	0	0	0	9 „
Outside 16ft. circle	0	0	0	1 „

The word "unknown" indicates that where (as with soft shot and black powder) the straggling pellets were numerous, they were not counted between the 4ft. and 6ft. circles. The letter (8), placed after the number 13, indicates that, from one of the six cartridges fired, there was a "string" of pellets thrown off from the main body of the charge, as shown in the accompanying illustration.

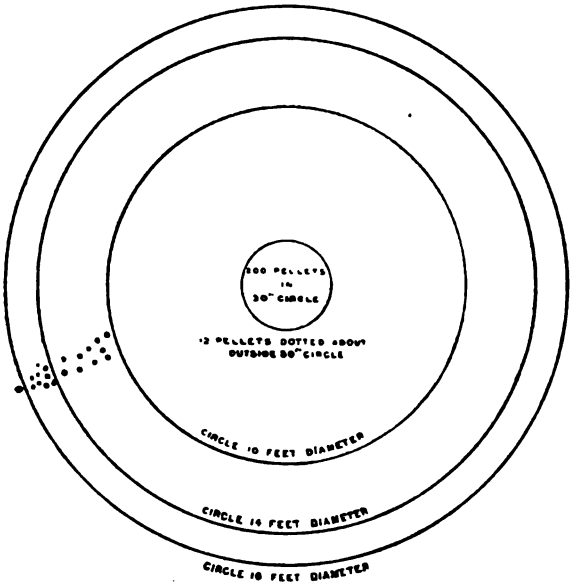

200 PELLETS IN 30" CIRCLE
12 PELLETS DOTTED ABOUT OUTSIDE 30" CIRCLE
CIRCLE 10 FEET DIAMETER
CIRCLE 10 FEET DIAMETER
CIRCLE 10 FEET DIAMETER

Fig. 1.—Quick-Burning Powder and Soft Shot.

Here it will be observed that, out of the entire charge of 1¼oz. of No. 6 shot, 200 pellets were placed in the 30in. circle; and, in the space between that and the 10ft. circle, a dozen pellets were scattered about. Beyond the 10ft. circle, however, on the left, there was a "string" of pellets, which appear as though they had been thrown off in a compact body, and kept together by a partial "balling" of the charge—a circumstance not unlikely to occur with soft shot, when acted on by such a quick-burning explosive as No. 2 black powder. With No. 4 black the results would probably be much the same as with Schultze; but we only tried the two powders mentioned in the table.

The fact that pellets are more or less crushed out of shape at the cone of the chamber—especially if the cone be short and abrupt—is, we think, made obvious by what occurred with two cylinder guns which were also used in these experiments. If the deformation of the pellets occurred at the choke, the proportion should be about the same with both powders; and there should be less deformation with cylinder guns. But the experiments did not support this supposition, as will be seen by reference to the records made by the cylinders—in one of which the cone was long and gradual, whereas in the other it was shorter and more abrupt.

Long-coned Cylinder. Straggling pellets:	Schultze Powder. Hard shot.	Schultze Powder. Soft shot.	No. 2 Black. Hard shot.	No. 2 Black. Soft shot.
Between 4ft. and 6ft. circles	15	16	unknown	unknown
„ 6 „ 8ft. „	0	1	6	2
„ 8 „ 10ft. „	0	(SS)	0	10 (C)
„ 10 „ 12ft. „	0	„	0	6

The (SS) indicate that there were two strings of pellets in different rounds with soft shot; one of these extended beyond the 9ft. circle, and the other beyond the 11ft. circle; but we have no record of the exact number of pellets. The (C) indicates that, in one round, there was a compact cluster of nine pellets just by the 10ft. circle; whereas only one pellet was placed in the same circle by the other five cartridges.

With the abrupt cone, the effects were much more marked than with the gradual cone, as will be seen by the next table:

Short-coned Cylinder. Straggling pellets:	Schultze Powder. Hard shot.	Schultze Powder. Soft shot.	No. 2 Black. Hard shot.	No. 2 Black. Soft shot.
Between 6ft. and 8ft. circles	19	35	unknown	unknown
„ 8 „ 10ft. „	(8)	14	30	unknown
„ 10 „ 12ft. „	„	0	7	39
„ 12 „ 15ft. „	0	0	1	11

From this abrupt-coned cylinder there was a "string" of pellets, even with the chilled shot, when propelled by Schultze powder. This, we conclude, must have been a consequence of the abrupt cone checking the free movement of the shot, and thereby causing the nitro powder to develop a much greater amount of strain than would be produced under ordinary conditions.

Deflections from Stone and Iron.

To ascertain the extent of the glance or deflection from stone, we fixed up edgewise a smooth York paving slab, which is much harder than sandstone, though not so hard as granite or flint. This was placed about 4 yards from the large target, and was fired at from a distance of about 25 yards, at different angles; and after each shot a measurement was taken of the deflection from the mark of the shot on the face of the stone to the splash of the pellets upon the target. The smaller the angle, the less departure there would usually be from

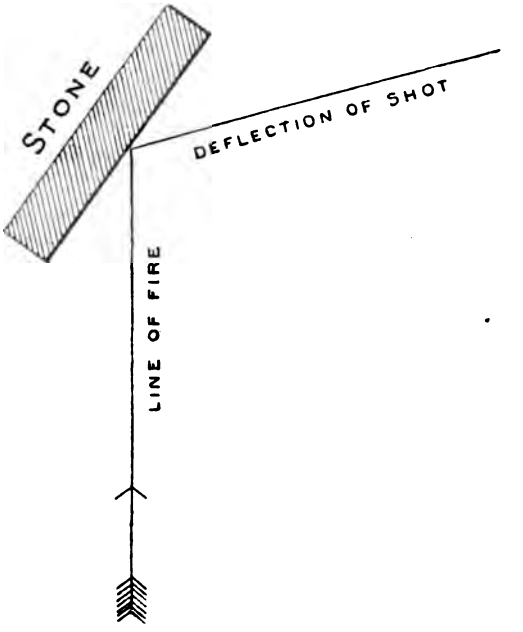


Fig. 2.—Deflection from Stone at Angle of 40°.

a straight line, and the less loss of force in the pellets. Generally speaking, there appeared to be but little difference in the extent of the deflection of soft and hard shot. The difference was most marked when shooting at an iron target, with its surface at right angles to the line of fire. Then the fragments of soft shot rebounded about 5 yards; and the hard shot, being more elastic, came back about 7 yards—the gun being at 40 yards from the target.

In carrying out the angular experiments with the stone slab, we used a choke-bored gun with No. 4 black powder, and the gun was

fired at about 25 yards distance from the stone. The accompanying diagram (Fig. 2) shows the deflection from the angle of 40°.

The next diagram (Fig. 3) shows an increase in the angle. Here the shot was deflected at about right angles from its previous course.

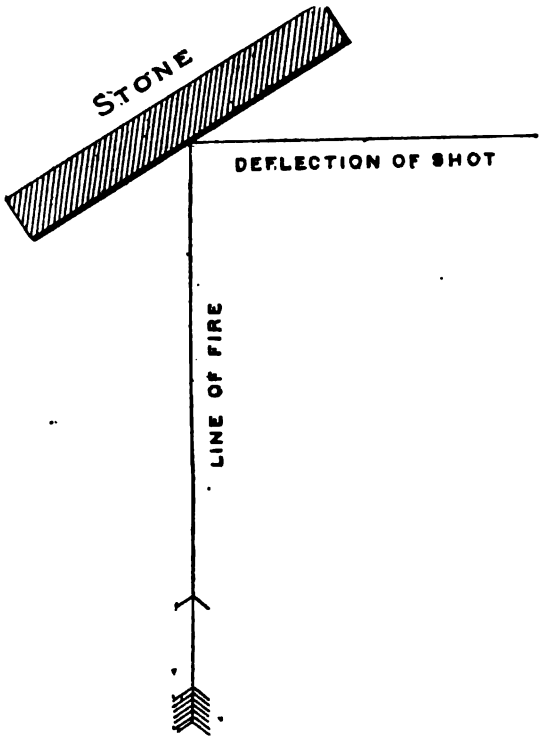


FIG. 3.—DEFLECTION AT RIGHT ANGLES.

In the fourth illustration, with a further increase in angle, the shot was deflected a little nearer towards the gun.

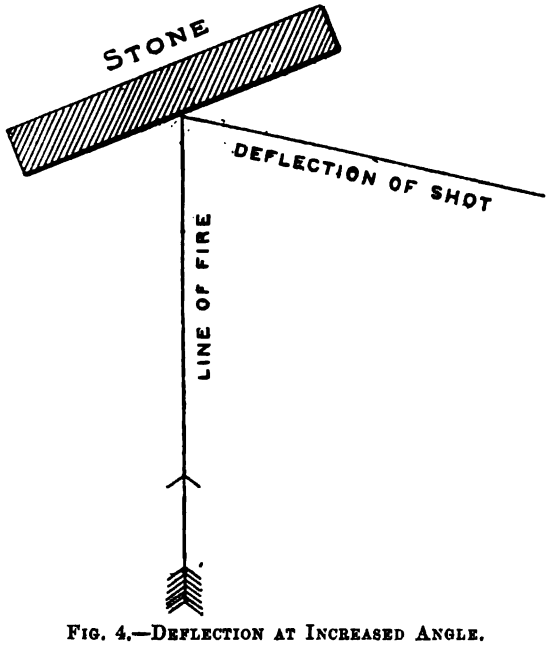


FIG. 4.—DEFLECTION AT INCREASED ANGLE.

With regard to the glancing of shot from wooden objects, as trees, wooden fences, &c., it was found that there was no appreciable difference between the hard and the soft shot. Neither kind glanced when the surface was rough or corrugated, as in the bark of a tree; but where the surface was smooth, and the pellets struck the grain lengthwise, they would be deflected to a much greater extent than from either hard stone or iron. When a charge was fired at a block of hard wood, the angle of incidence being only about 30°, the angle of deflection was about 90°. The reason of this appears to be that, if the surface is not too hard (and *if the pellets strike in line with the grain*), a groove is scooped out of the substance struck, as shown in the next illustration (Fig. 5). This groove turns the shot into the new direction with comparatively little loss of velocity. A somewhat similar result also occurs when moderately soft stone is struck.

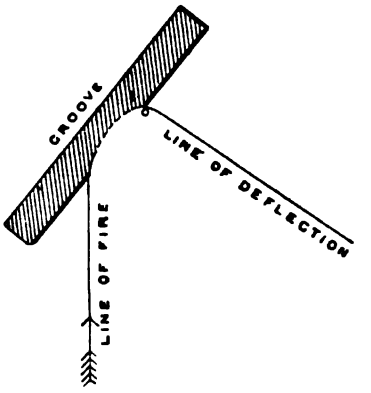


FIG. 5.—DEFLECTION FROM HARD WOOD.

On summing up the general results of these experiments we cannot but come to the conclusion, from the trials carried out with different guns, different powders, and different objects fired at, that the risk of injury from stray pellets is greater with soft shot than with hard, as the soft is more liable to get knocked out of shape, and thus to scatter about more wildly. We can thoroughly sympathise with those gentlemen who, with the laudable desire of limiting as much as possible the cause of accidents to life and limb, have prohibited the use of chilled shot on their estates; but the facts obtained appear to indicate that this well-meant restriction tends to perpetuate the evil rather than to check it. The moral, however, that especially needs to be drawn is the imperative necessity of the utmost care in the handling of fire-arms, whatever may be the variety of shot with which they are charged.

Anyone who has carried out many experiments at the target will be well aware that the best shooting guns, with carefully loaded cartridges, will occasionally scatter a charge of shot in a most unaccountable way. Round after round may be fired, and great regularity obtained with regard both to pattern and penetration; yet once now and then there will be a sudden falling off, and not one-third of the usual number of pellets may strike the target. Many instances of this may be found in the records of gun trials that have been published in our columns. And if such occurrences happen occasionally when every care is taken to obtain the most regular results, it is to be supposed that they will probably occur more frequently when there has been less care in the loading. Where, then, can such pellets go? Apparently they are scattered abroad in all directions; and a target of 20ft. in diameter might not be large enough to stop the whole of the pellets at 40 yards. In some cases, too, there may be an excellent pattern in the 30in. circle, yet one or more clusters of pellets will leave the main body, and, flying off at an angle, will miss the target by many feet.

[It seems not improbable that the different behaviour of successive cartridges in the same gun may arise from irregularity in the strength of the caps. A stronger cap than usual may produce a more sudden ignition of the powder charge, with a corresponding increase of crush of pellets in the cone, and the consequent scattering about of a larger number of mis-shapen shot.]

A consideration of these liabilities should induce men to pay more heed than they generally do to the risks they may inflict upon others. There are many shooters, nowadays, who fire cartridges by the thousand in the course of a single season. Let them consider that in every hundred cartridges there are about thirty thousand pellets, any one of which, if it takes a disastrous course, may possibly destroy another man's eyesight, if not his life. P.—T.

GLANCING SHOT—SOFT AND HARD.

(*Field*, Feb. 6, 1892; Vol. 79, p. 168.)

SIR,—I am inclined to think that some of the gentlemen writing on this subject have done scant justice to hard shot, probably from want of sufficient opportunities of arriving at a correct judgment. I am decidedly of opinion that the risks from glancing or rebounding shots are less with hard shot than with soft. Such an incident seldom occurs in covert where the trees are those having rough and corrugated barks; those most offending are beech and ash, and, in a less degree, sycamore and birch. Now, if a beech tree is struck with soft shot they flatten out on one side, leaving the other convex. These pellets take the most eccentric courses, as whenever the flat surface gets opposed to the air they alter their direction, and may start from the tree due west and end by going due east. They have rough edges, and make nasty wounds when striking hard enough to break the skin; but, unless the tree struck is at only a moderate distance, they do not retain their spherical form sufficiently to enter the bark, and consequently in most cases glance off in some direction or other; whereas, when hard shot is used, if the opposing bark be at anything near right angles to the line of shot, they will enter and remain there, and this at considerably greater distance from the gun than soft. Moreover, if they strike the tree at an angle they will still cut partially into the bark, and then will continue their course forward at something like a corresponding angle to that at which they struck, making due allowance for the angle and curve of the bark to their original line; and in most cases will be found to fly onward rather than return.

We are all fond of going rabbit shooting in very hard frosts, when the crust of the ground is bitten up as hard as a stone. Here there is great risk from shot of all kinds glancing, and the direction may be anywhere; in fact, no shots are really safe unless made in furzes, or the grass is strong and pretty long. But the most dangerous shooting of all is that of shooting on or near the ground where, like much of our down country, the fields are thickly strewn with flints lying on the surface. Here you have flats, rounds, and angles of every conceivable form, and it is utterly impossible to know in what direction the pellets may glance—sometimes so directly back as to strike the shooter; while men and dogs are liable to be struck in the most unexpected situations. My own practice in such fields has been, on seeing a man about to take a shot, to wheel quickly round and present my back to the game, not turning or looking round until I heard the bang, or was satisfied the quarry had got too far off to be shot at; in point of fact, I have, as boys would put it, always "funked" these fields more than any other situation in shooting.

In trying guns at the plate, it has been my habit to go to the right or left of the target—at a sufficient distance to ensure not being struck by an outside pellet—in order to listen to the shot coming up to the plate. Now, a good many of the men, either for supposed strength or ornament, put a moulding round the outer edge; from this shot continually glance, and, if not standing level with the face of the target, you are liable to be struck; and if a few yards nearer to the shooter, it will pretty nearly certain to be so when soft shot is used. They flatten out on the plate, if the gun is good, to the thickness of a thin card, and in this flattened condition it is utterly impossible to premise what direction they may take. I have sometimes found them hanging in the back of a rough jacket on returning home. When standing in a line with the target, it is seldom indeed that you get struck with a pellet of hard shot. From all these circumstances, which have frequently occurred to me, I can only conclude that the chances of accident from glancing or returning shot are really much greater with soft shot than they are with hard.

ONE WHO HAS FIRED SOME 20,000 TRIAL SHOTS AT MARKS.

Brighton, Feb. 3, 1892.

INFLUENCE OF SIZE OF SHOT ON THE SHOOTING OF GUNS.

(*Field*, June 29, 1889; Vol. 73, p. 922.)

SOME particulars relative to the influence of a difference in boring of gunbarrels on the shooting qualities of powders were given in a previous article [here reprinted at page 79]; and it may perhaps be of interest if we follow up this subject by a few somewhat similar particulars with respect to the effect of changing the size of shot when the gunbarrels and other conditions remain the same.

A short time ago we asked Mr. W. P. Jones to carefully try four sizes of shot from choke-bore and cylinder barrels. The sizes to be used were—No. 6, of 270 pellets to the ounce, to serve as the standard of comparison; No. 5½, also called "medium game shot," of 240 pellets per oz.; No. 5, of 218 pellets per oz.; and No. 4, of 174 pellets per oz. He used 42grs. of the same powder (E.C.) with 1⅛oz. of each size of shot, in Kynoch's "perfectly gas-tight" paper cases. The results, at the 30in. target, at 40 yards distance, were as follows:

CYLINDER BARREL.

	Pattern. Actual Pattern.	Pattern. Proportional.	Pattern. Difference.	Striking Force or Velocity. Force Velocity. Record. Ft.sec.	Striking Force or Velocity. Proportional Force. Velocity.	Striking Force or Velocity. Diff. of Velocity.
No. 6 shot...	119	—	—	1·96 = 529	—	—
No. 5½ „ ...	112	106	+6	2·25 = 540	2·25 = 540	0
No. 5 „ ...	99	96	+3	2·60 = 567	2·55 = 556	+11
No. 4 „ ...	82	77	+5	3·62 = 630	3·46 = 602	+28

CHOKE-BORE.

No. 6 shot...	199	—	—	2·09 = 564	—	—
No. 5½ „ ...	182	177	+5	2·39 = 574	2·40 = 576	−2
No. 5 „ ...	161	161	0	2·58 = 563	2·72 = 593	−30
No. 4 „ ...	126	128	−2	3·69 = 642	3·70 = 644	−2

The column marked "actual pattern," in the first portion of the table, gives the number of pellets of each size placed within the 30in. circle; the "proportional pattern" states how many pellets there would have been in that circle if the gun had placed on the target exactly the same proportion of the charge with all sizes of shot; and the "difference" column, with its *plus* and *minus* signs, shows by how many pellets the actual pattern exceeded or fell short of the true proportion. It will be seen that, with the three larger sizes of pellets, the cylinder barrel shot rather closer than it did with No. 6; but the choked barrel did so with one size only.

In the second division of the table a similar course has been followed, but with certain differences of detail, arising from the force-record not admitting of the same direct comparison as the pattern. The numbers on the scale of the force-gauge (or "force-ounces" as they were designated by Mr. Walsh) are units of momentum, based on weight and velocity, 1·00 on the scale representing a weight of 1oz. striking with a velocity of 1ft. per second, or any fractional part of an ounce striking with a corresponding increase of velocity. Thus, with No. 6 shot, 1·00 would represent the 270th part of an ounce striking with 270 ft.sec. velocity; with No. 5 shot, 1·00 represents the 218th part of an ounce striking with 218 ft.sec. velocity; and so on with other sizes of shot. In like manner, other records of "force per pellet," whether in whole or fractional numbers, are corresponding representations of weight and velocity—2·00 being indicative of a striking velocity of 540 feet per second with pellets of No. 6 shot (270 per oz.); while 2·16 represents 583 ft.sec. with No. 6, or 518 ft.sec. with No. 5½—the latter having but 240 pellets to the ounce.

But besides the mere difference in weight of pellets, there has also to be taken into consideration the natural advantage which heavy projectiles have over light ones in being less retarded by the resistance of the atmosphere. With single projectiles this can be accurately estimated by means of what is called the "ballistic co-efficient" (or $d^2 \div w$) of the shot. With charges of loose pellets it cannot be stated with the same exactitude; but for general practical purposes the advantage thus derived, as compared with pellets of No. 6, may be stated as about 2 per cent. with No. 5½ shot; 5 per cent. with shot of No. 5 size; and 14 per cent. with No. 4. In the above table, under the head of "proportional force or velocity," these additions have been made; and it will be observed that, in the cylinder barrel, the allowance exactly corresponds with the increased velocity of the pellets of No. 5½ shot; with No. 5 the increased advantage was much greater than the percentage allowance; and still more was such the case with No. 4. On the other hand, with the choked barrel, the advantage never came quite up to the percentage of increase; and with No. 5 shot in this barrel the velocity barely reached what it had been with No. 6.

In the next, the records are taken from a letter in the *Field* of July 28, 1888, in which Mr. W. Atkinson gave details of experiments:

	Pattern. Actual Pattern.	Pattern. Proportional.	Pattern. Difference.	Striking Force or Velocity. Force Velocity. Record. Ft.sec.	Striking Force or Velocity. Proportional Force. Velocity.	Striking Force or Velocity. Diff. of Velocity
E.C. POWDER:						
No. 6 shot...	235			2·05 = 553		
No. 5 „ ...	201	190	+11	2·70 = 589	2·67 = 582	+
J.B. POWDER:						
No. 6 shot...	229			2·08 = 562		
No. 5 „ ...	197	185	+12	2·43 = 580	2·70 = 589	−59
SCHULTZE POWDER:						
No. 6 shot...	213			1·89 = 510		
No. 5 „ ...	186	170	+16	2·44 = 532	2·46 = 536	− 4
BLACK POWDER:						
No. 6 shot...	208			1·84 = 497		
No. 5 „ ...	159	167	− 8	2·17 = 473	2·39 = 521	−48

These experiments he had carried out with No. 5 and No. 6, using different powders and kinds of wadding. The trials with No. 6 shot were confined to one system of wads, and we therefore limit our comparison to those tried under exactly the same conditions. Only one barrel, a full choke, was used; and the results are here set forth in the same fashion as in the previous table. The black powder used was Pigou and Wilks's Alliance No. 4.

It will be seen above that with all three nitro-compounds this gun shot closer with No. 5 than it did with No. 6; but with the black powder the reverse was the case. In regard to velocity, E.C. alone increased with No. 5 shot beyond the percentage allowance; with J.B. and the black powder the velocity of No. 5 was much below that of No. 6.

The next table is based on the records of the trial of three guns (12-bore, 24-bore, and 28-bore) with No. 6 and No. 4 shot—full details of which were published in the *Field* of Nov. 10, 1888 (here reprinted at page 186). All three barrels were choke-bores. The same method as to proportional results being applied as in the previous tables, the numbers come out thus:

	Pattern.			Striking Force or Velocity.		
	Actual Pattern.	Proportional.	Difference.	Force Velocity. Record. Ft.sec.	Proportional Force. Velocity.	Diff. of Velocity.
12-Bore Gun:						
No. 6 shot...	216			2·05 = 553		
No. 4 „ ...	132	136	−4	3·35 = 583	3·63 = 632	−49
24-Bore Gun:						
No. 6 shot...	185			1·68 = 454		
No. 4 „ ...	113	119	−6	3·02 = 525	2·97 = 517	+ 8
28-Bore Gun:						
No. 6 shot...	138			1·82 = 491		
No. 4 „ ...	96	89	+7	3·11 = 541	3·22 = 560	−19

It will be observed that the smallest bore shot closer with No. 4 than with No. 6, while the other two spread the charge rather more than the big pellets. And, as regards force, the 24-bore was the only one which showed more than the proportionate increase of speed with No. 4 shot.

The inference that may be drawn from the results of these experiments is very similar to that induced by the experiments with different powders previously recorded—viz., that it is not desirable to follow slavishly the method of loading adopted by any other man without endeavouring to ascertain whether it is suitable to your own gun as well as to his. It is a common practice with many sportsmen to use, in the second barrel, shot of a larger size than is used in the first; and, where the same barrel shoots the two sizes of shot equally well, there is a decided advantage in following this practice, because the heavier the pellet the better it maintains its force up to long distances; while, although the pattern may not be so large, it is better to miss entirely than to hit with shot which is powerful enough to wound, but too feeble to kill. It may happen, however, that from some idiosyncrasy of the gun, or from its use with some particular powder, the second barrel will not shoot large shot so well as it does that of a smaller size. Should such be the case, why take the trouble to carry two sorts of cartridges, when you can do better by having them all alike?

T.

TESTS OF THE HITTING FORCE OF SHOT.

(*Field*, Oct. 12, 1889; Vol. 74, p. 585.)

Controversies have arisen, from time to time, with reference to the relative merits of different methods of testing the shooting powers of sporting guns. Some persons prefer the time-honoured practice of firing at an empty powder-canister; and if the shot pierces both sides they are quite content—regardless of the fact that, if several canisters, of exactly the same size, and bearing the same labels, be weighed, or the thickness of the plate be gauged, they will often be found to differ considerably in substance. Others try their guns at old books, and, on giving their experiences in print, inform their readers that the shot pierced so many leaves; but what the quality or stoutness of the paper may have been is left to conjecture. When brown paper pads are obtained of the same make, there is a much better chance of comparison; but, as was found in some of the *Field* Gun Trials, in years gone by,* the pads supplied by the same maker differed in weight and toughness on different occasions, and consequently the records of two trials may not be so correctly comparable as they should be. The use of strawboards or cardboards, slightly separated from one another, are preferable to the close pad of paper, as giving a more equable resistance, and less springiness than the mass of sheets; but there is a liability, as with the pads, of variations in toughness and hygrometric qualities in different batches. With the view of obviating such variations, a gunmaker of our acquaintance proposed to adopt sheets of lead foil instead of strawboards; but, on getting estimates from the lead merchants, he found they would be much too costly for general use. Some months ago a correspondent gave his experience of the use of a frame fitted with bars of soap, into which the shot penetrated, and then the writer of the letter carefully measured the extent of the penetration of the pellets. This might be highly satisfactory to an enthusiast, with an unlimited amount of time at his disposal; but what other person would venture upon such an undertaking?

With any such system as these, if it be worked out as it should be to give reliable results, much more time would be required than any business person would be likely to devote to it; consequently, when paper pads, &c., are used, they are employed in a perfunctory sort of way, by counting only the sheets perforated by a very limited number of pellets. Some people are content to ascertain the number of sheets that are pierced by *one* pellet, others take *two*, and others *three*. In those *Field* gun trials at paper pads where three pellets were required to count, penetration in some of the rounds was scored by 0; for, although two pellets may have perforated a number of sheets, and many more have indented the surface, a third perforation was wanting to effect a record; and so the difference in position of two competing guns might depend on the fact that, in a wild shot with one gun, three pellets may have penetrated the pad, while in the other case only two may have done so. What became of the remaining three hundred pellets in the charge was entirely left out of consideration, so far as force was concerned. To get, however, an accurate representation of the general performance of a gun, the estimate should not be based on two or three pellets, but an average should be made from the number of shots that strike the pad and the number of sheets that each pellet perforates; but this would be too serious a task to be generally undertaken, as will be shown by the following extract from the *Field* of Sept. 14, 1878, in which Mr. Walsh described his experiences:

> The old brown paper test only gave the accidental force of three pellets, which sometimes were very far above the average of the charge. Now it is useless to have three strong pellets surrounded by a multitude of weak ones; and yet this is what often occurs without detracting from the character of the gun. We find that an increase of powder above a certain charge will frequently give this exceptional force to a few pellets, while the average force is at the same time not only not increased, but is absolutely reduced. Of course, this average may be arrived at by counting the perforations in every one of the brown paper sheets; but the task is an endless one, and in counting ten pads last week we occupied ourselves for more than three hours. We were led into this irksome performance in comparing our new machine with the brown paper pads, each being shot at by the same charge. Usually there was a correspondence, but occasionally the divergence was so remarkable that, in order to arrive at the cause, we were obliged to ascertain the average penetration of the whole of the pellets striking the pads, and in doing so discovered the frequency of the variations to which we have alluded.

Now, in the *Field* Gun Trial of 1878, carried out a few months before the above remarks were written, there were 1800 rounds fired, and consequently 1800 brown paper pads to be examined; and if the pads had been thoroughly investigated, in the way described above, they would, at the rate of three hours to ten pads, have occupied a person 540 hours, or nine hours a day for ten weeks, to complete the task of reckoning them; whereas, with the force-gauge, the pellets on the 10-inch plate are counted as part of the ordinary pattern, and, the number being thus known, the force-record may be read off at once from the printed tables.

In the year following the above-mentioned trial, the Boulengé chronograph, which had previously been used for ascertaining the velocities of rifle bullets and larger projectiles, was applied to ascertain the speed of small shot. To Mr. John Rigby belongs the honour of first giving publicity to information on that subject, which he did in the following paragraph in a letter in the *Field* of May 17, 1879:

> I have ascertained the true time by the chronograph, and it varies, with the charges in general use, from one-sixth to one-seventh of a second, the latter being the time for a good 12-bore, with 3¼drs. and 1⅛os. of No. 6 shot. These times correspond to a mean velocity of 720ft. and 840ft. per second respectively—which are of course higher than the final or striking velocity at 40 yards.

A few weeks later, Mr. R. W. S. Griffith, who had for some months been carrying out chronographic experiments, sent us full details of the results he had obtained, which extended over seven sizes of shot (No. 2 to No. 8), with many variations in the loading, and with both Schultze and black powders; and the experiments were tried, not alone with the chronograph, but with the force-gauge and with brown paper pads also, besides the recoil machine. From these records (published in the *Field* of June 14 and July 26, 1879) we propose to make a few extracts, bearing on points recently discussed in our columns, with reference to the effect of unduly increasing charges of powder,

* See report of the 1875 Gun Trial, and the effect of change of pads mentioned on page 109; also alteration in number of sheets in the 1878 trial, as mentioned on page 116.

and also to the relation which the mean velocity of the shot (as ordinarily taken by chronograph) bears to the actual force with which the pellets strike the target at the end of 40 yards. We hold that the chronographic mean velocity for that distance does not give, in many cases, at all a correct notion of the "hitting" powers of the gun, but, on the contrary, leads to a false idea of the final velocity of the pellets, owing to the mutations arising during their passage from gun to target, any indication of which is concealed by a record that merely states the average speed for the entire distance. It would occupy too much space to go through the variations in loads of shot used in Mr Griffith's experiments, and we will therefore limit our extracts to those which relate to the same quantity of shot (1oz.), propelled by three different charges of two sorts of powder, Schultze and black (C. & H. No. 4). The pattern represents, as usual, the number of pellets placed in the 30in. circle; the force, that recorded by Mr Walah's force-gauge; while the velocity given is the mean speed for 40 yards, as taken by the Boulengé chronograph. Each record is an average of three shots, the separate details of which are stated in the original tables.

No. 2 Shot (1oz., of 116 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	80	4·24	847 f.-s.	84	4·78	856 f.-s.
3 ,,	76	4·89	913 ,,	88	5·30	914 ,,
3½ ,,	62	4·75	968 ,,	63	4·94	985 ,,

Of the brown paper pads, 38 sheets were penetrated with 2½drs.; the number was increased to 46 sheets with 3drs., but fell off to 44 sheets with 3½drs. The records of the paper pads represent only one kind of powder, viz., Schultze, there being no separate record for black.

No. 3 Shot (1oz., of 139 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	76	3·55	818 f.-s.	89	3·56	810 f.-s.
3 ,,	83	4·47	905 ,,	80	4·25	919 ,,
3½ ,,	82	4·47	963 ,,	91	4·41	965 ,,

Paper pads.—35 sheets were penetrated with 2½drs., 40 with 3drs., and 40 also with 3½drs.

No. 4 Shot (1oz., of 178 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	102	2·09	807 f.-s.	98	1·98	809 f.-s.
3 ,,	100	2·86	890 ,,	99	2·75	893 ,,
3½ ,,	85	3·17	965 ,,	92	3·35	963 ,,

Paper pads.—The sheets penetrated were—30 with 2½drs., 35 with 3drs., and 37 with 3½drs.

No. 5 Shot (1oz., of 219 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	113	2·17	816 f.-s.	121	2·33	817 f.-s.
3 ,,	118	2·38	874 ,,	109	2·35	883 ,,
3½ ,,	108	2·61	942 ,,	107	2·28	927 ,,

Paper pads.—24 sheets were pierced with 2½drs., 32 sheets with 3 drs., and 30 sheets with 3½drs.

No. 6 Shot (1oz., of 270 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	160	1·57	759 f.-s.	163	1·73	781 f.-s.
3 ,,	147	1·68	860 ,,	159	1·87	858 ,,
3½ ,,	123	1·87	900 ,,	153	1·88	905 ,,

Paper pads.—18 sheets were penetrated with 2½drs., 26 sheets with 3drs., and 26 sheets also with 3½drs.

No. 7 Shot (1oz., of 346 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	198	1·06	761 f.-s.	226	1·09	766 f.-s.
3 ,,	211	1·23	829 ,,	215	1·20	842 ,,
3½ ,,	174	1·16	895 ,,	185	1·31	901 ,,

Paper pads.—16 sheets were penetrated with 2½drs., 22 sheets with 3drs., and 21 sheets with 3½drs.

No. 8 Shot (1oz., of 438 pellets).

	Black Powder.			Schultze.		
Charge.	Pattern.	Force.	Velocity.	Pattern.	Force.	Velocity.
2½drs.	259	0·82	776 f.-s.	284	0·84	791 f.-s.
3 ,,	246	0·73	816 ,,	305	0·89	823 ,,
3½ ,,	266	0·81	898 ,,	250	0·88	881 ,,

Paper pads.—13 sheets were penetrated with 2½drs., 17 sheets with 3drs., and 16 sheets with 3½drs.

It will be observed that, in every instance, the increase of the powder from 2½drs. to 3drs. produced a considerable addition to the *mean* velocity; and it likewise caused a corresponding rise in the record of the force-gauge as well as of the paper pads, except in one instance—with No. 8 shot and black powder. On the other hand, although the further increase of the powder-charge, from 3drs. to 3½drs., produced another addition to the mean velocity, it also, in the majority of instances, either caused a falling off in the records with force-gauge and paper pads, or made little or no addition to them. It is a well-known fact that many guns shoot some sizes of shot with more regularity than others, as the pellets "chamber" in the barrel more evenly. Such was evidently the case with the gun used in these experiments, and the fact is indicated by the records with pads and force-gauge, as well as by the pattern; but the *mean* velocity does not show it.

Now, if it be true that, when the force-gauge record is in conflict with the mean velocity of the chronograph, "so much the worse for the force-gauge," how are we to account for the discrepancies? Are we to assume that the force-gauge acts properly, for three rounds in succession, when the first increase in the powder-charge is made; and that it gives false records for three rounds in succession when the second increase of powder takes place? Also, are we to suppose that this curious performance, of accuracy with the first series and inaccuracy with the second, is repeated by mere accident with different sizes of shot; and that the paper pads reiterate such performances, likewise by mere accident? We trow not; for a much more reasonable explanation is afforded by the evidence of the chronograph itself.

Some six or seven years after the publication of the results which we have here quoted from, Mr. Griffith carried out a still more extensive series of chronographic experiments. He fired over two thousand cartridges, with different charges of powder and sizes of shot, at distances ranging from five yards up to sixty yards, and ascertained by chronograph the mean velocity given with each charge for each distance. We extract a few examples, showing how greatly the ending velocities of different sizes of shot, and of different charges of the same shot, vary when the mean velocities are alike, or nearly so. In the following table the first column of figures shows the mean velocities recorded for the 40 yards range; and, as the chronograph does not furnish the actual velocity of loose shot either at the muzzle or at any other distance, we give the mean velocities of the same charges for the five yards next to the muzzle, and also for another five yards commencing at 40 yards from the gun; and the difference of the velocities 40 yards apart will show how little the mean speed of the whole range represents the actual velocity of the shot when it has traversed the entire distance. The figures here given are not the results of a single round each, but are the average of a series, as with those above.

Mean, Beginning, and Ending Velocities of Shot Charges.

Shot.	Powder.	Mean Velocity of 40 yards	First five yards.	Five yards from 40 to 45.	Falling off of speed.
1oz. No. 1 ...	2½drs.	883 ft.sec.	1059 ft.sec....	697 ft.sec.	362
1½oz. No. 5 ...	3½drs.	880 ,,	1130 ,, ...	586 ,,	544
1½oz. No. 7 ...	3½drs.	880 ,,	1168 ,, ...	579 ,,	584
1½oz. No. 4 ...	3drs.	872 ,,	1134 ,, ...	628 ,,	506
1oz. No. 6 ...	3drs.	872 ,,	1154 ,, ...	605 ,,	549
1oz. No. 2 ...	2½drs.	868 ,,	1084 ,, ...	673 ,,	361
1½oz. No. 5 ...	3drs.	865 ,,	1127 ,, ...	605 ,,	522
1½oz. No. 6 ...	3½drs.	858 ,,	1121 ,, ...	562 ,,	559
1½oz. No. 6 ...	3drs.	840 ,,	1119 ,, ...	577 ,,	542

It will be observed that, not only do ending velocities differ considerably when mean velocities are equal, in cases where the records of different sizes of shot are compared together, but that similar results happen, in a less degree, when shot of the same size is used; for the last two lines in the above table show that, of two charges of No. 6, the one which had 18ft. advantage in mean velocity, stands 15ft. lower than the other after traversing a distance of 40 yards. These extracts from chronographic records will, we think, serve to explain why there was often a very great falling off in the penetration shown by both paper pads and force-gauge in the previous table, where the proportion of powder to shot used was much more excessive than in the last-mentioned experiments.

With respect to comparisons of records made by force-gauge and paper pads, we may here quote the results of some experiments carried out, in November, 1881, by Mr W. P. Jones, of Birmingham. Instead of taking the records of paper pads and force-gauge by separate shots, Mr Jones fixed a pad on the target, immediately above the 10-in. plate of the force-gauge, and consequently the two records were taken simultaneously by pellets from the same cartridge. The charge used was 3½drs. of powder and 1½oz. of No. 6 chilled shot (270 to oz.); and for estimating the penetration of the pads, all the sheets were reckoned that were broken by two pellets. Black powders alone were used, with the same cases and wads throughout. We can only afford space for the averages, which are based on six shots with each kind of powder, except

as regards the paper pads, the averages of which are based on four shots—no pads having been attached to the target for the other two rounds. The summary of results is as follows:

Powders.	Pattern.	Force-gauge Record.	Brown Paper Pads.
C. & H. coarse basket grain	177	2·12	15½ sheets.
,, extra coarse ditto	209	2·13	17 ,,
,, No. 4 T.S.	209	2·13	16½ ,,
,, No. 6 T.S.	218	2·06	16½ ,,
,, No. 6 Diamond	230	1·96	16½ ,,
Hall's Letter A	226	2·02	17½ ,,
,, Letter B	196	2·07	16½ ,,
Pigou & Wilks's Alliance No. 4	226	2·10	16 ,,

In these experiments the paper was thicker than was used in the first experiments recorded above, and consequently fewer sheets were penetrated. Taking the average of the whole, it will be found that on dividing the number of sheets by 8, the quotient agrees pretty closely with the force-record. In some instances, however, it is rather above, and in others rather below; but it must be borne in mind that, although pads and force-gauge were struck by portions of the same charge, they were not struck by the same pellets. If two very fast pellets happened to strike the pad, they would considerably influence the record of penetration, as they alone would count; if, however, those two pellets happened to strike the force-gauge, their influence would be attenuated by fifty other pellets, the whole of which would be included in the force average. Consequently the records from the pads may naturally be supposed to be liable to wider degrees of variation than those from the force-gauge; and such is found to be the case on comparing the records. Thus, four successive shots with the same powder gave, as the force-records, 2·02, 1·93, 2·04, and 2·05, the highest record being 6 per cent. more than the lowest. The pad records from the same four shots were 18, 16, 15, and 16 sheets respectively—so that the highest record was 20 per cent. more than the lowest. It is not surprising that such should be the case. The force-gauge records were based on an average of 52 pellets, or one-sixth of the whole charge; and the record of the paper pads depended only upon two pellets, or the 150th part of the whole charge; so that it can easily be imagined which of them would be most liable to fluctuation.

Many more instances could be quoted, if necessary, in support of the arguments advanced above; but we think sufficient has been stated to show that the chronographic mean velocity of a charge of shot, when taken for one distance only, is not so satisfactory a method of comparing the force with which pellets strike the object fired at, as either the paper pad or the force-gauge; and that the latter is less liable to fluctuation than the former, as it represents a much larger proportion of the charge—besides which it carries out the same work in considerably less time. T.

EXPERIMENTS WITH THE "FIELD" FORCE-GAUGE.

(*Field*, Sept. 19, 1896; Vol. 88, p. 468.)

For several years past, since we adopted the use of the chronograph for recording the velocities of shot-charges, we have but seldom used the "force-gauge," which was designed by the late Mr Walsh, and used by him at the last of his *Field* gun trials. Recently, however, we have made some experiments for the purpose of ascertaining how the two instruments, the force-gauge and the chronograph, would work in combination. Four records could thus be taken from each round fired, viz., velocity, striking force of the pellets, recoil of the gun, and the shot pattern; and we hoped that, by taking these records simultaneously, means would be afforded of tracing the cause of some of the curious vagaries which occasionally happen with cartridges that apparently are loaded exactly alike, but give very different results.

Before deciding to adopt this course, we overhauled the force-gauge, and tried various experiments to see how far certain alleged defects in the working of the instrument were borne out by experience. One of the alleged defects was that, owing to the rebound of the shot from the steel plate of the gauge, the full force of the pellets was not properly recorded.

Soon after the force-gauge was first made, Mr Walsh, in order to test the difference, tried various experiments and, among others, placed a layer of felt over the steel plate, with the view of capturing and retaining the pellets, and thereby recording their full force; but, of course, the captured pellets would have to be removed after each round, or else the weight to be moved would increase with every shot. Eventually, however, he gave up the task as hopeless, and continued the use of the steel-plate as before.

Recently we followed in Mr Walsh's footsteps by trying some further experiments; and the course we adopted was to have a thin board of soft pine instead of the steel plate, and to use a new board, of the same weight, with every round. Of course, if this were done, the expense of carrying out lengthy experiments would be considerably increased; but we wished to see whether there was such an improvement in accuracy as would compensate for the addition in cost, time, and trouble. The result, however, showed that, instead of the capture of the pellets increasing the register of force, it had the reverse effect, as will be seen by the following tables. Ten rounds, under exactly the same conditions, were fired at both kinds of plates. We do not, however, give the rounds in the order of firing, but arrange them in order of numerical pattern, for convenience of comparison. The velocity stated in the table is the mean velocity of the shot-charge for a range of 40 yards.

Experiments with the Steel Plate.

	Total Pattern.	Pellets on gauge.	Force per pellet.	Velocity. Ft.sec.	Recoil. Ft.lb.
	215	30	1·80	815	30·0
	207	26	1·88	822	31·2
	200	30	1·77	800	32·1
	199	24	1·92	795	31·0
	197	35	1·89	801	32·1
	195	40	1·80	806	30·0
	188	29	1·86	821	31·5
	185	28	1·79	780	29·4
	180	27	1·82	798	32·0
	175	29	1·72	806	32·0
	175	25	1·92	788	29·7
	173	23	1·96	817	29·3
Average...	190	29	1·84	804	30·9

Experiments with the Wooden Plates.

	Total Pattern.	Pellets on gauge.	Force per pellet.	Velocity. Ft.sec.	Recoil. Ft.lb.
	212	38	1·47	800	32·1
	210	29	1·66	789	30·2
	205	27	1·59	793	29·8
	198	20	1·45	791	31·1
	192	34	1·47	805	30·0
	190	33	1·58	817	32·3
	186	30	1·63	787	31·2
	180	24	1·46	806	30·5
	180	24	1·25	808	32·0
	179	35	1·54	806	31·1
	175	32	1·44	824	32·1
	170	25	1·44	801	32·0
Average Wood...	189	29	1·50	802	31·2
Average Steel ...	190	29	1·84	804	30·9

The main feature is that, although the averages were so close together in other respects, the amount of force recorded was more than 20 per cent. higher with the steel plate, from which the shot rebounded, than from the wooden board, into which the pellets penetrated and became imbedded, thus expending the whole of their force.

The reason why the wooden plate only averaged 1·50 pellet-force, whereas the steel plate showed 1·84, is, we think, to be accounted for in this way:—The metal of which shot is made, especially the so-called chilled variety, possesses a considerable amount of elasticity; therefore, when the shot strikes the plate, the force-gauge not only registers a force which would suffice to bring the pellets to rest, but there is also registered an accession of force caused by the rebound of the pellets. Shot pellets generally rebound from the iron target to a distance of about four or five yards.

In order, if possible, to still further elucidate the theory above set forth, a very large number of experiments have since been carried out with jets of water and also with steam impinging upon the plate of the force-gauge; and the results obtained may be briefly summed up by stating that, generally speaking, the greater the rebound of the impinging matter, the greater was the amount of force registered on the gauge.

The above records, even with the steel plate, are low in comparison with others that we have published from time to time with a similar charge (3drs. of No. 4 black powder, and 1⅛oz. of No. 6 shot). This we attribute to the unfavourable state of the atmosphere, as the experiments were carried out in cold damp weather early in the spring; and the records of velocity and recoil are low as well as those of the force-gauge. In more favourable weather, some months previous, the same powder had given 40 to 50 ft.sec. higher velocity, and several foot-pounds more recoil, when loaded in the same way and fired out of the same gun; but, as is usual when the velocity is high, the pattern was then much lower, averaging about 160 instead of 190.

EXPERIMENTS RELATING TO RECOIL.

SOME NOTES ON RECOIL.

(*Field*, March 9, 1889; Vol. 73, p. 349.)

ACTION and reaction being equal, it is generally assumed that the recoil of a gun may be estimated from the weight and muzzle velocity of the shot, when the weight of the gun is likewise known; and in books for students one finds propounded questions similar in character to the following: "If a Martini-Henry bullet (weight 480 grains) is projected from the barrel with a muzzle velocity of 1320 feet per second, what will be the velocity of the recoil of the rifle (weighing 8¾lb.), and what the energy of recoil in foot-pounds?"

On working out this problem, the velocity of recoil is found to be 10·34 ft.sec., and the energy 14·6 ft.lb. And if, in like manner, a similar investigation is made with reference to 1½oz. of shot, propelled from a 7lb. gun with a speed of 1200 ft.sec., the velocity of recoil is estimated at a trifle over 12 ft.sec., and the energy nearly 16 ft.lb. Accordingly, if you have had the recent experience of bruising your shoulder by firing a Martini-Henry rifle, a feeling of relief may be produced on your being told that its recoil is nearly 10 per cent. less than that of your ordinary smooth-bore; and that, if you wish your shot gun to treat you as gently as the Martini, you must increase its weight to 7½lb., and then the recoil of the two weapons will be just about equal. We can fancy the grim smile of Tommy Atkins, if you were to let him fire off your 12-bore, with 3drs. and 1½oz., and then try to persuade him that it kicks more than his rifle.

On comparing theoretical and practical results in this way, one is led to the conclusion that the ordinary formula does not meet all the conditions of the case, and that something requires to be taken into the estimation for which no provision has been made. Action and reaction are equal, beyond question; but a correct equation can hardly be made if some of the factors are left out; and such would appear to be done in the case under consideration. One additional factor is introduced in the formula given by our correspondent "Fleur-de-Lys" (page 198). He has included the weight of the powder as well as the weight of the shot; but that alone does not suffice to meet the requirements of the case; it still leaves the Martini with less kick than the 12-bore, and merely reduces the calculated difference to 7 per cent.

The statement made by "Fleur-de-Lys," that "recoil begins at the moment the projectile begins to move up the barrel," is perfectly correct; and Mr. Pike was also correct in his conclusion that the recoil which took his punt gun off the forward rest, and left the muzzle "looking into the water," did not practically divert the shot from the line of aim, because the shot was out of the barrel before the kick-off took place. There may probably have been a preliminary "jump," raising the muzzle of the gun by a few minutes of angle; but this would be of little importance with a punt gun scattering hundreds of pellets among a flock of ducks, seeing that each minute of rise in the muzzle only causes a difference of an inch in the elevation of the shot at the end of 100 yards.

The movement produced in the gun after the shot has left the muzzle is very different from that which occurs while the projectile is still within the barrel; and the nature of the movement would be influenced by the evenness or irregularity of the resistance with which the recoil is met. Thus, a person shooting from the right shoulder with a stock cast off for the left eye, would be likely to have his gun slewed round in similar fashion to the field piece described in the following extract from the official "Text Book of Gunnery, 1887," by Major Mackinlay, R.A.:

> A field gun, after it has recoiled, seldom or never points in the same direction as when laid, because a certain lateral twist has taken place depending on one wheel meeting with greater inequalities than the other in recoil. If one wheel is skidded and the other is accidentally left loose, the muzzle slews violently round on recoil to the side of the unskidded wheel; but this does not affect the accuracy, as this side movement does not begin till the projectile is out of the bore.

That this movement would not manifest itself until after the shot had left the gun, becomes intelligible enough by the light of the French experiment alluded to by "Fleur-de-Lys," in which the velocity of recoil of a 24-cm. gun was found to be rather over 12 f.s. when the shot left the muzzle, and 17 f.s. at ·048 of a second after the departure of the projectile. The length of this gun is not stated, but, as the diameter of the bore was 9½in., its length would probably be 10ft. or more; and while the shot was moving the whole length of the bore, the recoil movement was barely 1½ inch. It was found, too, that it was not till ·048 sec. after the shot left the muzzle that the recoil movement attained its highest speed; hence, supposing the shot to have had only the moderate muzzle velocity of 1300 f.s., the projectile must have been more than 60ft. distant from the gun when recoil reached its maximum velocity. Moreover, if, for the purpose of estimating the energy of recoil, we square both these velocities, we find that 17 times 17 are 289, or double the product of 12 times 12; so that about one-half of the energy of recoil was conferred while the projectile was in the gun, and the rest was superadded after the shot had quitted the barrel.

It would thus appear that recoil must include something more than is provided for in the formulæ alluded to above. Let us, then, look at what happens on the gun being fired, in order to ascertain whether anything occurs which is not ordinarily taken into consideration.

On a charge of gunpowder being ignited, however great may be the resulting pressure, there is, of course, no motion produced until resistance is overpowered in some direction or other; and so, in experiments carried out by Sir F. Abel and Captain Noble, when a couple of pounds of powder were inclosed in a very strong steel case, and ignited—with a resulting pressure of more than 40 tons per square inch—the box, being able to withstand the strain in every part, remained perfectly quiescent. If, however, the steel had given way at one point, there would have been a corresponding motion in the opposite direction, in like manner as when a defective gun-chamber bursts on the left side, the gun is thrown to the right, and *vice versa*. In the ordinary course of events, however—barrels remaining intact—there is no movement to right or left, but, as the shot offers least amount of resistance, it is pressed forward by the evolution of the gas, and a simultaneous backward movement is produced in the gun, though differing in rapidity according to the difference in weight of the bodies that are set in motion.

As the projectile passes through the bore, however, the forward and backward movements are not dependent solely on the relative weight of shot and gun. There is a considerable amount of friction in the barrel, varying with the nature of the boring and the projectiles used. In a smooth-bore, loose pellets are jammed against the walls of the barrel; and the smaller the size of the shot, the more numerous are the points of contact, and the greater the friction; while large pellets offer much more resistance than a spherical ball of the full size of the bore. In a rifle, too, an elongated bullet encounters more resistance than a round ball, and the longer the cylindrical portion of the bullet, the greater is the friction. Again, a rifle with a rapid twist offers greater resistance than one with slow twist—other things being equal; and a foul barrel causes more obstruction than one which is clean Now, in all such instances, this frictional resistance to the forward movement of the shot has a tendency to drag the gun away from the shoulder. Hold a rifle barrel in your hands, and get somebody to force a bullet through from breech to muzzle by steady pressure; and a notion may then be formed of what goes on when a shot is fired.

In order to get an idea of the amount of resistance encountered by a Martini-Henry bullet, we requested Mr. Griffith to test it in his lever-press apparatus, and he found that a dead-weight pressure of 60lb. was required to move the bullet at the breech; that the resistance gradually increased for nearly a foot, the pressure then required being 100lb. (or nearly 1500 times the weight of the bullet); after the next 6in. the resistance gradually diminished, and for the last few inches the weight required was 55lb. These differences are evidently due to variations in the bore, which is slightly enlarged towards the breech, and the depth of the grooves is progressively reduced for some distance, thereby tightening the grip on the projectile; but when the depth becomes uniform, the bullet begins to work more freely, and the resistance gradually diminishes. It must be borne in mind, however, that the pressure above mentioned is merely the result of a slowly-acting dead weight on a cold bullet; and that when the projectile is "jumped up" by the violent action of the powder gases, frictional resistance would probably be much increased.

Taking the various resistances into consideration—whether they arise from the rifling, or foulness in the barrel, or large charges of shot, &c.—it may be concluded that their general tendency is to counteract, and temporarily nullify, some of the backward pressure which is exerted on the breech of the gun. An increase of frictional resistance to the moving shot would also tend to lessen the muzzle velocity; for the same speed cannot be expected from a foul barrel as from a clean one, or from a charge of No. 8 as compared with shot of No. 1 size. If, however, velocity and weight of projectile are alone to be considered in the estimation of recoil, the result of the greater amount of friction should be a reduction of recoil, corresponding with the falling off in muzzle velocity. Practical experience, however, tells us that a foul barrel recoils more than a clean one; that a rifle with a sharp twist kicks more than a slow one; and so on.

Another matter that should not be overlooked is the fact that the powder has something besides shot to drive out of the barrel. Air has also to be expelled; and that is scarcely *une quantité négligeable*. Take the case of an ordinary 12-bore gun, with 1¼oz. of shot, which is driven out with a muzzle velocity of about 1200 f.s. The 1¼oz. is accepted as a basis of calculation, but what about the air?

When a flat-headed projectile of 12-bore calibre is traversing the open air with a speed of 1200 f.s., it encounters atmospheric resistance to the extent of about 6¼lb. If we assume the 1¼oz. charge of shot, with a wad in front, to be the flat-headed projectile, the resistance of the air would thus be equal to about 90 times the weight of the shot. When the shot first begins to move at the breech, the air-resistance must be comparatively trifling. But as velocity increases the obstruction becomes more important; and as the shot nears the muzzle, and the air becomes condensed before the rapidly-advancing charge, the resistance offered is doubtless much greater than would be opposed to the passage of a bullet in a free atmosphere.

How much the actual pressure of the condensed air in the barrel may be it is difficult to say, but that it is very considerable is beyond question. Last summer we were witnessing some experiments carried out by Mr. Griffith, at the Schultze Company's works, and we requested him to try and ascertain a few shot-gun velocities at much shorter distances than are usually tested. He found, however, that the condensed air in front of the charge broke the wire of the chronograph some time before the shot got to the end of the barrel, and thus vitiated the records, by making the velocity appear much lower than it obviously ought to be. On removing the wire beyond the influence of the condensed air, there was a considerable increase in the record of velocity, instead of a decrease, as should have resulted had not the wire been prematurely broken in the previous experiment, and consequently lengthened the period of time recorded by the chronograph. From a rough calculation made, it appeared that the breakage of the wire must have occurred when the shot advancing up the barrel was at least 6in. distant from the muzzle; and it may be concluded that the air close to the shot-wad was likely to be more condensed than that which broke the wire.

From what has now been said, it will be evident that the pressure acting on the breech cannot be estimated merely by the work performed in driving out of the barrel a shot of given weight; because a considerable amount of force is expended in overcoming frictional resistance and expelling air. This force acts as a counterpoise to a portion of the breech-pressure; and, so long as the shot remains in the gun, the effect of this extra work may be disregarded with respect to its influence on recoil. But the case is altered as soon as the shot passes out at the muzzle. A relief from friction and compressed air instantly ensues; the breech-pressure suddenly loses its counterpoise, and, being now free to operate to the full extent of its power, it violently jerks back the gun, and so produces the "kick," the severity of which depends upon the magnitude of the counterpoise which has ceased to act.

The result is very similar to what may occur when competing athletes are striving at a "tug of war." A team may be gradually overmastered by its opponents with little actual movement, but if the one team lets go the rope when the other is pulling, a sudden "recoil" takes place—which may be a slight jerk or a complete sprawl, according to the amount of force exercised on both sides at the moment of disjunction.

This sudden recoil, or kick in the gun, is the movement which leaves the muzzle of Mr Pike's punt gun "looking into the water," and which shatters the nerves of Tommy Atkins; and it performs its part without interfering with the line of flight of the shot. If the projectile is diverted, it must be by the action of the initial recoil which occurs while the shot is in the barrel, and which, though much less demonstrative than the other, should not be disregarded. T.

LETTERS ON RECOIL AND JUMP.

[A number of letters on this subject appeared in the *Field* in the early part of 1889—some before and others after the publication of the above article. We reprint several of the most important among them, omitting a few passages which occurred in the course of a rather warm discussion, without adding to the elucidation of the subject.]

SIR—Mr. T. M. Pike's statement, that recoil does not take place till the projectile has left the muzzle, must not pass unchallenged. Recoil is due to the longitudinal pressure of the powder gas on the end of the bore, and acts in the opposite direction to the motion of the shot. Recoil, therefore, begins at the moment that the projectile begins to move up the barrel, and increases regularly with the increasing velocity of the projectile until the moment when it leaves the muzzle. At this point the velocity of recoil is at its greatest.

As in every gun the centre of gravity is below the axis of the barrel, the force of recoil causes a tendency to rotate about that point; that is, the muzzle goes up and the breech goes down. This resultant effect is termed "jump," and has a very considerable influence on the range of guns; so much so, that in the 12-pounder breechloading field gun depression has to be given up to a range of 400 yards. . . . . Jump is aggravated by a much-bent stock, as the centre of gravity then becomes lower than ordinary, and the tendency to rotate is increased.

I will endeavour to explain the why and wherefore of "jump." The 12-pounder and its carriage, being rigidly connected when the gun is fired, may be taken as one piece. The recoil causes the point of the trail to press violently into the earth, while the wheels have a tendency to rise; that is, there is a rotatory effect of the whole system about the point of the trail. As this rotatory motion gives a jerk up to the muzzle, the gun has, up the range of 400 yards, to be pointed so that the prolongation of the axis of the bore falls below the target.

To explain it in another way—suppose the gun to be placed on a horizontal plane, and the axis of the bore to be parallel to that horizontal plane, when the gun is fired the projectile would leave the muzzle at an angle of elevation of so many minutes, according to the nature of the gun. This angle is called the "angle of jump."

As to the velocity of recoil, to be very particular, the highest speed is attained just after the projectile has left the muzzle. In an experiment made with a French gun of 24 centimetre calibre, it was found the velocity of recoil, on the projectile leaving the muzzle, was 12·86 feet per second; while it attained to a maximum of 17 feet per second, ·048 of a second later.

The formula employed to determine the velocity of recoil would be:

$$W u = (w \times w') V$$

W = weight of gun carriage in pounds.
w = weight of projectiles.
w' = weight of powder charge.
u = velocity of gun and carriage in feet per second.
V = velocity of projectile in feet per second.

This, of course, would only apply where the gun and carriage are free to recoil without check.

The velocity of recoil of a small arm could be ascertained by the same formula, supposing the gun or rifle were arranged so that it could move back without hindrance.

The violence of recoil directly depends on the product of the weight of projectile multiplied by its muzzle velocity when it leaves the barrel. If you wish to increase the muzzle velocity without increasing the recoil, you must lighten your bullet and increase your powder charge, thus keeping $W V$ constant.

I will close with a short extract from the range table of the twelve-pounder gun;

Range.	Elevation or Depression.
100 yards	17′ depression
200 yards	11′ depression
300 yards	5′ depression
400 yards	2′ elevation
500 yards	9′ elevation.

The absolute jump is 22 minutes, and, as about 5 minutes elevation is required for 100 yards, the actual depression given at 100 yards range is 17 minutes, as shown. The 4in. breechloader of 22cwt. has only 6 minutes jump; the 6in. 5 tons, 7 minutes. Each gun varies.

FLEUR-DE-LYS.

SIR,—Having read the letters on this subject, I beg to offer the following as a solution of the apparently knotty question: Recoil, which is accelerating, and is in fact two separate recoils, is due to two distinct forces, which follow each other with such rapidity that they are virtually one. The first recoil is due to the combustion of the powder (which only acts equally on all sides whilst the powder is burning), its action being principally on the base of the cartridge case and the base of the projectile. The amount of strain that the breech therefore receives varies, *ceteris paribus*, according to the weight of and resistance offered by the projectile. The second recoil, which comes into play as soon as the gases leaves the barrel, is due to the inrush of air into the barrel to fill the vacuum that the explosion has caused. So instantaneous, however, is the whole action that the second recoil forms an accumulative force, which bears out the experiments mentioned by "Fleur-de-Lys," where the recoil was found to reach a culminating point ·048 of a second after the projectile had left the bore.

The formula quoted by "Fleur-de-Lys" for calculating recoil is only approximately true with black powder, and totally incorrect with nitro-compounds, on account of the properties and powers of each being so widely different. This formula is based on the supposition that the rifle is driven back with the same force that the

bullet is propelled forward, the difference of velocity being due to their unequal weights. But such is not the case; the bullet, which starts first on the combustion of the powder, is followed by the force of the gases, which always attack the weakest point, whilst the recoil is due to the wave pressure set up by the resistance offered by the projectile and the barrel to the free expansion of the gases, together with the vacuum before mentioned. There are also other causes which tend to augment this recoil in black powder, such as fouling, smoke, and solid products, &c.; but of these more anon.

The above theory I have often proved by attaching to a cartridge case (say a 12-bore pigeon-case) a wire about 12in. long, sufficiently strong to support both the weight of the case and the powder (filled to the brim), when on igniting the charge I have found it burn out harmlessly, and at the same time to only slightly vibrate the wire. But on repeating this experiment with but a few grains of black powder, or with a nitro-compound enclosed with a tight wad, I have had the wire bent double, and very often blown out of my hand. This tends to show that black powder must have a projectile in itself, which, by resisting the free action of the gases, causes a recoil even though the explosive is not enclosed, or its free action otherwise resisted.

That this is, without doubt, the case, the following tables will show, by their enumerating the products of combustion of the different explosives:

BLACK POWDER.

Gases.		Solids.	
Carbonic acid	27·18	Carbonate of potassium	24·97
Carbonic oxide	2·58	Hyposulphite ,,	18·63
Nitrogen	11·17	Sulphate ,,	12·20
Sulph. hydrogen	·81	Sulphocyanide ,,	·13
Marsh gas	·09	Nitrate ,,	·11
Hydrogen	·05	Potash	1·73
Oxygen	·06	Carbonate of ammonia	·02
		Sulphur	·27
Total gaseous products	41·94	Total solid products	58·06

Another authority gives a still lower figure for the gaseous products of black powder, viz.:

Carbonic acid	20·12
Carbonic oxide	·94
Nitrogen	9·98
Sulph. hydrogen	·18
Hydrogen	·02
Marsh gas	·14
Total gaseous products	31·38

Nitro-compounds, however, have a much larger proportion of gases, *e.g.*:

Nitrogen	10·60
Carbonic acid	69·20
Carbonic oxide	5·20
Hydrogen	4·50
Total gaseous products	90·20

Thus leaving only 9·80 as the total solid products.

From these tables it will be seen that the products of black powder are, on an average, 64 per cent. by weight solid and only 36 per cent. gases, whilst in nitro-compounds the proportion is 10 to 90 respectively.

Thus, on combustion, besides propelling the projectile, black powder must expel 64 per cent. by weight of solid products in the shape of fouling and smoke, which in the Martini-Henry makes about 50grs. in addition to the weight of the bullet, and accounts for the great difference of recoil in this rifle when black powder or a nitro-compound is used. Most of your readers must have noticed the same thing with the nitro-compounds for sporting purposes, though the difference in this case is hardly so forcibly marked.

As regards jump, mentioned by "Fleur de-Lys" to be very considerable in field guns, it is simply due to the resistance offered to recoil being so very much below the axis of the barrel, which naturally gives the gun a rotatory motion round the trail. This disadvantage was especially prominent in the Soudan War, where the trail of the guns were found to dig into the sand and cause the projectiles to fly high. The bend in the stock of a rifle or gun causes the same thing, but in a very modified form; and the more bend there is in a stock (as in a pistol) the greater will be the jump. In the Maxim gun (though the trail rests on the ground in a similar manner to field guns), where the barrel shoots back horisontally, and where the chief resistance is in continuation of the axis of the bore, this jump is not so perceptible.

It seems to be a very common error, even with men having a good practical knowledge of guns and powders, to compare carbon mixtures and nitrate compounds upon the supposition that their properties and powers are the same, and thus to find their theories and calculations totally upset by experiment.

Since writing the above—dealing, as it does, with the subject generally and on a broad scale, and which, unfortunately, was too late for last week's publication—I have had the pleasure of reading your more detailed article, and therefore take the liberty of adding to my original, if you will kindly spare me the space.

The crooked stock of a gun, that is either cast on or cast off, causes the weapon to shoot to one side of the mark—the reason being that, like the trail of a field piece, which is below the axis of the barrel, the resistance to the recoil in this case is to one side, causing the gun to revolve round the end of the stock (as round a pivot) to that side to which the barrels lean. This accounts for the slewing round of the guns of this type mentioned in "Some Notes on Recoil."

As regards recoil itself, the question when taken in every minute detail is much more complex than the usual formula used for calculating its force would lead one to imagine. "Fleur-de-Lys" slightly altered it by adding the weight of the powder charge; but I am afraid I quite fail to recognise this as a factor, at least no more than two-thirds of it, and even then it is in the form of the solid product of the combustion, and can hardly be termed the powder itself. Mr Pike, I imagine, was much nearer the mark when he mentioned "the force necessary to drive out the gases themselves;" he saw plainly that there was a something which gave recoil to a blank cartridge besides the resistance of the wad, but he was unable to account for it satisfactorily. I think that if he has had the patience to follow me so far he will agree with me that it is not unlikely that the solids and smoke, and the resistance of the air in the barrel, together with the inrush of the surrounding air to fill the vacuum after the gases leave the barrel, should cause this apparent phenomenon.

Personally I have always rejected, on the face of it, the popular formula (though it is still taught at the School of Musketry), and therefore I have refused to use it in any calculations; but that its inaccuracy should amount to an absurdity, I only learnt for the first time from your exposing that fact in your last edition. And certainly a theory that gives the recoil of a 12-bore gun (weight 7lb. and with 1¼oz. of shot) in excess of the ·45-bore Martini-Henry, is entitled to be regarded at least with suspicion by anyone having any practical experience of the subject.

With the theory of the two forces you mentioned in your article of March 9 (p. 197) I beg to most heartily agree with you, especially in the reaction after the bullet has left the barrel, consequent on one of the forces of the counterpoise being released—which tends to support the experiments with the French gun, where the recoil was greatest after the projectile had left the barrel; whilst it is evident that the air in the bore must resist the passage of the projectile, and be compressed in the act of expulsion. I will, with your permission, add both these forces to those of the formula I shall enumerate below.

I will now briefly try to trace the action of the gases and projectile in the bore of a gun. Each grain of powder, by its combustion, as the ignition reaches it, forms gases $\frac{1}{10}$ of its own weight, and about 250 times its own bulk (at ordinary temperature and barometrical pressure), whilst it evolves 740 units of heat, which raises the whole to about 4000° Fahrenheit, and exercises a pressure of 6500 atmospheres, or about 43 tons to the square inch, and at the same time, leaves $\frac{1}{10}$ by weight of solid products (which at this stage are in a liquid form). It is therefore natural that these solids should, by their interruption to the free action of the gases, create a wave pressure, and thus, together with the air in the barrel, cause in the first instance a resistance greater than that of the friction of the gases and projectile against the sides of the bore. From this it is evident that the backward pressure, which is the greater, causes the gun to recoil, which takes place soon after the projectile has started—the order that their inertiæ are overcome being according to their respective weights. In a nitro-compound, however, this is perhaps reversed at the outset, and would account for the impression that these powders, when fired from a rifle, have been known to give to men of sensitive touch—viz., that the first movement of the weapon on being fired was forward, and not backward. Following the projectile as it now passes down the bore, the recoil slightly increases (according to the friction offered); but directly it leaves the muzzle the recoil is augmented by the release of one of its counter-forces, when the friction of the projectile, that has up to this point been carrying the weapon with it, is replaced by the inrush of air into the vacuum, thus bringing the recoil to a climax (as is found to be the case by experiment), ·048 of a second after the projectile has left the bore.

Thus it would appear that, in order to calculate the force and energy of recoil, the following should be taken into consideration, viz.: (1) weight of arm; (2) weight of projectile; (3) weight of solid products; (4) weight and force of the air in the barrel; (5) friction (comprising size of bore and nature of rifling); (6) initial velocity; (7) reaction on the projectile leaving the bore; (8) wave pressure; (9) force of the inrush of air to fill the vacuum caused by the gases.

From which it is evident that the more accurate manner to estimate recoil is to do so by practice! and not by theory.

HERBERT WOODGATE, 24th Regt.

Lyric Club, London, March 7, 1889.

[Some comments on the above letter are included in an article in another column; see page 201.—ED.].

SIR—"Fleur-de-Lys" is too positive in his correction of your correspondent Mr. Pike's statement that recoil—that is, the recoil that we see and feel—has no effect on the flight of a shot. There is no doubt Mr. Pike is perfectly correct.

There is a great deal of recoil noticeable with the carbine, and it is frequently, if not generally, more evident with a good shot than with a bad one, for the reason that an experienced shot holds his weapon as lightly as possible to avoid cramping the muscles. I have frequently at target practice with my regiment, when a known good shot is firing, seen the muzzle of the carbine jerked upwards 9in. or 10in. at each shot—giving anyone who was not aware that the recoil produced no effect on the projectile, the impression that the bullet had gone to the stars; and yet bullseyes or centres were registered at every shot.

The action of an explosive gas is almost wholly in the direction of least resistance—always supposing, which is the case with every weapon, that there exists a direction in which the gas encounters much less resistance than in any other. When a gun or rifle is fired there is a momentary pressure on the shoulder (not the recoil that we see), caused by the inertia of the shot; but this is rapidly relieved as the shot, with accelerating velocity, moves down the barrel.

Your statement in your article on recoil, that, during the passage of a rifle bullet, there is an actual tendency to drag the rifle from the shoulder forwards, is undoubtedly quite correct. This, in conjunction with my explanation of the origin of the real recoil, fully explains why anyone firing a rifle experiences a greater shock than he does with a smooth-bored weapon.

What we understand by recoil is produced only indirectly by the explosive gas, and directly by the atmosphere. When a gun is fired, as soon as the shot has left the barrel the force of the explosive gas is exercised on the air in front of the muzzle, which it drives forward with the same energy that it has expended on the shot, creating thereby a vacuum immediately in front of the muzzle, and beyond this vacuum a zone of diminished atmospheric pressure, or partial vacuum, as it is sometimes absurdly called—an unpardonable solecism. In front of this, again, a zone of atmospheric compression is created, when the air, in addition to its own bulk, receives the bulk of the displaced air. The vacuum thus created is formed, of course, in the barrel as well as in front of the muzzle. Instantly after the explosion the compressed air rushes back to fill this vacuum, and rushes down the barrel with a force precisely the same as that of the gas itself, because action and reaction are equal and opposite.

If a gun were perfectly straight, a direct blow on the shoulder would be felt; but as the stock is bent, and the line of the barrels produced passes over the shoulder, it has a tendency to make the weapon rotate about the point of support—the heel-plate. This is the action we notice, and the blow caused by the air rushing down the barrel and striking the breech end of the barrel is what we feel. As the passage of a rifle bullet down the grooves has a tendency to pull the gun forwards away from the shoulder, the air drives the rifle backwards against the shoulder with greater force, because there is more play and more recoil is felt. I can illustrate the existence of this vacuum in a somewhat striking manner. My house is situated three-quarters of a mile from Hounslow Powder Mills. At serious explosions our windows are broken, but the glass flies outwards, not inwards, because the pressure of the air outside is lowered. On one occasion the sashes of one window were forced out of the frame, and a door in the interior of the house pulled off its hinges, both being drawn in the direction of the explosion.

"Fleur-de-Lys's" statement that the depression given to a 12-pounder gun at short ranges is necessitated by the recoil is quite incorrect. Having served at one time in the Royal Artillery, I can assure him there was no depression necessary with smooth-bored guns, elevation following point-blank. This puts him quite out of court. The necessity for this elevation arises from the fact that a shot, on leaving the bore of a rifled gun, is revolving about its axis at a speed, on an average, of about two and a half miles per minute. More than double hurricane velocity is consequently the velocity of the current of air carried round with it. At short ranges, as the projectile is close to the earth, this current is in contact with the ground, and becomes compressed, and reaction upwards follows, striking the shot on its under surface, and causing it to rise until equilibrium is established above and below. At greater ranges the shot is too high for the current to be affected. On account of inequality of pressure caused by this current, the shot is also deflected to the right at all ranges, and is allowed for.

E. G. M. DONNITHORNE, Lieut.-Col.

SIR,—Colonel Donnithorne has slightly misunderstood my letter. I contended that jump *begins* before the bullet has left the bore, but, as recoil continues afterwards, jump, a direct resultant of recoil, must continue too. The recoil of a carbine *has* an effect in making it shoot high, but this effect is small compared with the violent up-throw of the muzzle which takes place *after* the projectile has left the barrel. Jump and recoil begin while the bullet is moving down the bore, but are greatest just after it has left the muzzle.

The explanation about the 12-pounder B.L. gun is rather a startling one, but its fallacy is very easily proved. I have seen the 12-pounder fired from the brow of a hill, and, although the shell was a long way above the ground directly it had left the muzzle, the elevation for similar ranges was identical with that given when the gun was fired on level ground. The charges for the old smooth-bores were so small, compared with the weight of the gun and carriage, that their shooting point blank is readily accounted for. Mackinlay's "Text Book of Gunnery" gives "jump" as the reason for the depression given in modern guns at short ranges, so that I have rather a strong authority on my side.

With reference to the latter part of Captain Woodgate's letter, I do not agree with him that the force necessary to expel the powder gases themselves from the bore of a gun are the cause of pressure and recoil—at any rate, to an appreciable extent. That a blank charge, when fired in a gun, may cause considerable pressure is a well-known fact; and the crusher-gauge has registered as much as 5 tons to the square inch in a heavy R.M.L. gun, when there has not even been a wad over the cartridge. The explanation of this I take to be as follows: In small arms, and in the latest types of heavy breechloading ordnance, the cartridge is ignited in rear, while in radially-vented guns it is ignited four-tenths of its length from the base. As, therefore, the hinder portion of the charge is converted into gas first, it drives that part of the powder which is yet unconsumed in a mass up the bore, practically making it into a light projectile, and thus causing pressure. The resistance of the air in the gun to expulsion by the gases increases the internal pressures, and therefore the recoil. These two agents I consider account for by far the greater portion of the stresses generated in firing a blank charge; and I believe that, were a gun loaded with a charge of powder only and fired *in vacuo*, the cartridge being ignited from the front, the resulting pressures would be found to be very small indeed compared with those obtained on firing a similar gun with a similar charge in atmospheric air and igniting the cartridge near the base. Unfortunately, this is only a matter of conjecture, as it would require extensive apparatus to make the experiment, even on the smallest of scales.

The theory that the violent kick of a rifle is caused by the sudden inrush of atmospheric air after the projectile has left the muzzle, does not seem to me at all a sound one. If this is the case, we will suppose that a vacuum is formed in front of the muzzle in any gun or rifle; then it follows that the violence of the kick would vary directly as the sectional area of the barrel; and, therefore, the kick of a 12-bore gun with a similar charge and muzzle velocity should be far greater than a Martini-Henry, which is of much smaller calibre; but we know it is not. Another point, the pressure of the air is only 15lb. on the square inch. Would this be enough to cause appreciable recoil? I think not.

FLEUR-DE-LYS.

SIR,—I notice two letters in the last *Field*, in which the theory is put forth that the inrush of air into the barrel is the cause of the greater part of the recoil. I have made the following calculation to show that such is not the case. The momentum of the particles of gas and other products of combustion would doubtless cause the pressure in the barrel to fall somewhat below the atmospheric pressure, but anything approaching a perfect vacuum is highly improbable; and even supposing that a perfect vacuum were formed by the explosion, the force resulting from the inrush of air would be comparatively small. Let us see what it would really amount to.

A cubic foot of air of normal density weighs about 530 grains, and about 12·5 cubic inches would fill a 12-bore barrel 30in. long; so that the 12·5 cubic inches of air would weigh a trifle under 4 grains. The velocity with which air will rush into a vacuum is about 1298ft. per second, which is also about equal to the muzzle velocity of the charge. Again, a pellet of No. 5 shot (218 pellets to the ounce) is almost exactly 2 grains in weight; and if we project two such pellets (weighing 4 grains) down the barrel with a velocity of 1298ft. per second, the

energy expended on the bottom of the bore would be just about equal to that given out by a column of air rushing down. Now two pellets of No. 5 form less than the hundredth part of an ounce of No. 5 shot; so that the recoil due to the air rushing down would not equal the hundredth part of the recoil caused by imparting the muzzle velocity to a 1oz. charge of shot. H. P.

NOTES ON RECOIL AND JUMP.

(*Field*, March 16, 1889; Vol. 73, p. 384.)

Our previous article (page 197) touched on certain phenomena connected with recoil which are observable between the setting of the shot in motion and the occurrence of the "kick" which so distinctly emphasises the departure of the shot from the barrel. Some amount of momentum had been imparted to the gun while the projectile was moving from breech to muzzle; a sudden accession to this momentum was received on the disjunction of barrel and shot; and after these had been driven asunder, the momentum would be further added to by the outrush of gases, which, impinging on the external air, thrust back the barrel from which they are emitted, in like manner as a rocket is driven in a direction opposite to the mouth of the tube from which its flame rushes forth.

Recoil from firing Powder without Shot.

The effect of the outpouring of gases from the gun varies with the nature and quantity of the powder, which has a considerable effect on recoil, independently of the weight of projectile. If, however, we take the ordinary formula alone into consideration, there should be no recoil unless a projectile is used; but it would be idle to assert that such is the result. Of course, when a gun is fired with blank cartridge, the recoil is much less than when the gun is shotted; but recoil there is beyond question, and it increases with the quantity of black powder used, although without any shot.

A week or two ago we had an experiment carried out with a 12-bore gun, loaded with 3drs. of C. & H. No. 4 powder, and fired from Mr. Walsh's machine rest, the spring balance of which was screwed up to a resistance of 60lb; which may be taken as having a somewhat similar effect to the resistance of a man's shoulder. As no shot was used, the paper cartridge case was reduced in length, so as to allow only the ordinary amount of turnover on the wad. On the charge being fired, the indicator on the spring balance was moved from 60 up to 64. When the cartridge case was entirely filled with No. 4 powder (the quantity then used being 7½drs.), the register was 74. When, however, 1¼oz. of shot was added to 3drs. of powder, the record rose to 84.

With a Schultze charge of 42grs. (the equivalent of 3drs. black), no effect whatever was produced upon the spring balance screwed up as above stated, when the powder was fired without shot; and even when the screw was relaxed, and the indicator put back to 0, Schultze gave no record; whereas 3drs. of black moved the indicator from 0 to 10. With 1¼oz. of shot added, black powder moved the indicator from 0 to 42; while Schultze moved it to about 35 from the zero point. We may conclude, therefore, from this experience of Schultze powder without any shot, that it would not be a very desirable compound to charge a rocket with.

As bearing on the difference between black powder and nitro-compounds in producing recoil, some very pertinent remarks are made by Mr. Herbert Woodgate, in a letter previously printed (pp. 198-200). He points out how largely the black powder gases are loaded with solid residue when they leave the gun, and also shows how much larger a proportion of the original weight of the nitro-compound is converted into gas. But even more remarkable than the additional percentage by weight is the greater body of gases from the nitro-compound. Taking the first analysis of black powder quoted by Mr. Woodgate, because it runs much closer than the other to the best quality of sporting gunpowder, we will put the volumes of gases into comparison with those of the nitro-compound of which he also gives an analysis. We do not know from which of the nitro-compounds this particular analysis was made, but it does not appear to be either Schultze or E.C., and they differ from one another more or less; yet, although not directly representing these sporting nitro powders, it may serve to exemplify the difference in characteristics of nitro-compounds as opposed to the old black explosives; and the difference will be all the more striking in the example quoted by Mr. Woodgate, from the fact that in this sample the characteristic features are more strongly marked than in the sporting powders coming within the same category.

But variations are not wholly confined to nitro-compounds, for black powders likewise differ considerably in the volumes of gas evolved. As regards the meaning of the word "volumes," in the special sense here used, we may briefly say, without going into minute details, that if a cubic inch (or cubic foot, or other measure) of black powder is fired, it gives off about 250 volumes of the same size (whether cubic inches or cubic feet, &c.), the gas being measured when cold; and an equal weight of a nitro-compound may give off more nearly 1000 cubic inches (or feet) under similar conditions. The relative number of volumes of the different gases from equal weights of powder, as deduced from the percentages given in Mr. Woodgate's letter, are as follows:

Black Powder.	Volumes.	Nitro-compound.	Volumes.
Carbonic acid	137	Carbonic acid	354
,, oxide	20	,, oxide	42
Nitrogen	89	Nitrogen	84
Hydrogen	6	Hydrogen	502
Other gases	7		
Total	259	Total	982

It will be observed that more than half the whole body of gas from this nitro-compound is hydrogen; of which there is a merely nominal quantity in the black explosive. Now, hydrogen is an extremely light gas, being only about one-fourteenth part of the weight of ordinary atmospheric air, whereas carbonic acid gas is more than half as heavy again as air; and there is a law with respect to the diffusibility of gases, according to which a light gas is more rapidly diffused than a heavy one—the light gas mingling with the heavy at a rate proportionate to the square root of their densities. Consequently, if a gas one-fourth the density of air were brought into contact with the atmosphere, it would be absorbed therein twice as rapidly as one which equals the air in density; while the converse would be the case with a very heavy gas. And it may be assumed, therefore, that as carbonic acid gas is about twenty-two times as heavy as hydrogen, the latter would be diffused nearly five times as rapidly as the former.

Practically, however, this would only come into operation to a comparatively limited extent with Schultze and similar powders, because a considerable amount of nitrate of barium or potassium is introduced in the manufacture, and there is a much larger proportion of solid residue than stated in Mr Woodgate's analysis, and consequently a smaller proportion of gas products. Besides the permanent gases, however, a large quantity of water is formed by the explosion of the powder; and this, in the form of vapour, would add considerably to the body of gaseous matter in the gun-barrel.

The application of these tedious particulars may be made in this way. When a shot is fired from a gun loaded with black powder, there is a rush of gases which exceed the atmosphere in density; besides which the gases are loaded with particles of solid matter which considerably exceed their own weight. On the other hand, the gases from the nitro-compound are of rather less average density than the atmosphere, and are not burdened by so immense a mass of solid particles, but are supplemented by a considerable body of steam, which also is lighter than the air. When the rush of gases, &c., from the black powders occurs, there is a loud report from the violent concussion of the heavy mass of gas, &c., with the atmosphere, waves of air are borne long distances away, the gases disperse slowly, and smoke comes curling out of the barrel for some time afterwards. When the nitro-compound is fired, the report is less; and the air-waves not being so extensive, the effect is more local, the gases are quickly diffused in the atmosphere, and there is very little indication of their lingering in the barrel.

Inasmuch as action and reaction are equal, these outward effects may be expected to have a counterpart in the back-thrust of the gun. So long as the gases remaining in the barrel exceed the pressure of the atmosphere, they would be adding to the momentum of recoil; the more extended the time, the greater the effect; and the powder which is the most prompt in "clearing out" will add least to the back pressure. The rapid condensation of the steam into water may also be an element in the reduction of the recoil from nitro powders.

We do not give much credence to the statement that recoil results from the air rushing into a vacuum in the barrel; for it seems to us that the barrel has no vacuum. Until the pressure of the gases therein is reduced to the pressure of the atmosphere, the gases would pour out, but the air could hardly rush in; and we are of opinion that the "kick" would practically be over before the air could force an entry.

Differences of Recoil with Equal Velocity of Shot.

We frequently have heard it said, or seen it stated in print, that if a nitro-compound gives the same amount of muzzle energy as black powder, there must be the same amount of recoil in the gun. This assertion was denied, many years ago, by sportsmen in the habit of using Schultze powder. They were perfectly content with the results,

without troubling their heads with theories; and we are quite of opinion that they were correct in their practical conclusions.

Different varieties of black powders have also their differences of recoil. It has been found, with big guns, that more recoil is given with the large-grained powders adopted to lessen the stress in the barrel, than with the smaller grain previously in use. But in such cases it must not be forgotten that the powder-charge has been largely increased; and if, in the same gun, a 35lb. charge is used instead of 30lb., in order to produce the same muzzle velocity, it is not very surprising that there should be more recoil, although in a calculation based merely on muzzle velocity and weight of shot there would be no difference.

Without dwelling, however, on what occurs in artillery practice, we may give a few particulars as to what has been found to result from the use of different powders in ordinary shot guns, and therefore take some records from the *Field* gun trial of 1879, in which black powders alone were used. In order to avoid the complication which would arise from giving all the charges, we extract those only in which the same weights of powder and shot were employed by several competitors. We add the weight of the guns, and likewise the pattern and force recorded. The pattern is given because the "kick" is believed to be influenced by the choke, and the extent of the choke will be indicated by the pattern; while the force record will show that the gun which kicks most does not necessarily hit hardest. In these trials, the spring balance of the machine rest was screwed up to 80lb. resistance.

In all the 12-bore guns here given the shot charge was 1⅛oz. of No. 6, and the results (arranged in the order of greatest recoil) were as stated below. They are the averages of twenty-five rounds from each gun.

Weight and Variety of Powder.	Amount of Recoil.	Gun's Weight. lb. oz.	Average Pattern.	Pellet Force.
3¼ drs. C. & H. No. 4	112	7 1	180	2·01
,, ditto	111½	6 14	210	2·39
,, coarse basket grain	111½	6 7	174	2·25
,, P. & W. No. 4	111	7 4	204	2·31
,, ditto	109	7 4	207	2·23
3 drs. C. & H. No. 6	107½	7 4	223	2·02
,, ditto	107	7 3	224	2·22
,, ditto	102½	6 9	162	2·07

In the 16-bores, with 1oz. of No. 6 shot, the results were as follows with the charge that was mostly used:

Weight and Variety of Powder.	Amount of Recoil.	Gun's Weight. lb. oz.	Average Pattern.	Pellet Force.
2¾ drs. P. & W. No. 4	113	6 7	144	2·12
,, ditto	106½	6 7	161	2·15
,, C. & H. No. 4	106½	5 11	170	2·23
,, coarse basket grain	105½	6 1	153	2·19
,, P. & W. No. 4	105	6 4	157	2·07
,, C. & H. No. 6	104	6 5	166	2·03
,, ditto	104	6 0	150	2·10

In the 20-bores, 1oz. of shot was likewise generally used, but the powder charge varied so much with different competitors that only the following four adopted equal quantities:

Weight and Variety of Powder.	Amount of Recoil.	Gun's Weight. lb. oz.	Average Pattern.	Pellet Force.
2½ drs. P. & W. No. 4	105	6 0	133	1·77
,, C. & H. No. 3	104½	5 13	160	2·16
,, P. & W. No. 3	101½	5 13	150	2·30
,, C. & H. No. 6	95	5 13	174	1·90

Some of the variation in recoil of guns of the same weight, using equal charges of the same powder and shot, must doubtless be due to other influences, such as peculiarity of boring, difference of wads, variation of turnover, and so on. Extra tightness in the wads, and increase of turnover in the cartridge case, have a material effect in developing the force of the powder, because that force is not a fixed amount, dependent upon the quantity used; and under some conditions 3drs. may develop more force than a much larger charge fired under other conditions.

Effect of Turnover of Cartridge Case.

The turnover of the case has a considerable influence on the amount of force developed by the powder, more especially with the nitro-compounds; and very few persons have any idea of the amount of resistance given by the coiled paper or crimped brass end of the case. We were told, several years ago, by a civil engineer, that he had cut out the base of a brass "perfect" case of No. 16 gauge, and applied weights to drive out the wads and shot enclosed therein, and it took about 100lb. dead pressure to force the charge through the crimped end.

A few weeks ago, when Mr. Griffith carried out the experiment, mentioned in our last article (page 197), of forcing a bullet through a rifle barrel, he likewise tried an experiment with paper shells of 12-gauge. They were Eley's salmon-coloured cases, which are of the same quality as their green ones. The extent of the resistance naturally varied with the amount of paper rolled over; and the pressure required to overcome the resistances was as follows: With ⅛ inch turnover, 125lb. dead weight; with ¼ inch, 145lb.; with ⅜ inch, 170lb. But when the charge is once forced out of the case into the barrel, a few pounds suffice to push it through the smooth-bore—the amount varying from about 10lb. with ordinary 12-bore wads, to 18lb. with the tighter *Field* and felt wads of 11¾ gauge. Where, however, the barrel is choked, increased pressure is required at the constriction, the weight requisite being about 20lb. with the 12-bore wads, and 25lb. with those of 11¾ gauge.

The great resistance in the cartridge case, however, is not solely due to the paper turned over, but results from the combined effect of the pressure behind and the stoppage in front of the shot, which causes the pellets to jamb tightly against the walls of the barrel; and this resistance has to be overcome in addition to that of the paper turned over. Consequently the same resistance would not be incurred by cartridges containing no shot.

Commencement of the Recoil Movement.

The great amount of pressure produced in the chamber before the turnover is forced open does not affect recoil; for it is only when the shot begins to move, that reaction takes place. But the extent of the reaction will depend on the degree of impulse imparted to the shot; and a quick-burning powder will, by giving greater initial speed to the shot, also cause an earlier back movement.

About twelve months ago we published (*Field*, Feb. 11, 1888) an article giving an account of some experiments carried out by Mr. Griffith to ascertain the time taken by the shot in its passage down the barrel when different powders were used—the chronographic records being made from the fall of the hammer to the arrival of the shot at different distances from the breech. From that article we take the following particulars relative to the times of black powder (C. & H. No. 4) and Schultze for the first 6in. of the barrel, and for the remaining 2ft.:

Extent of Movement.	Black Powder.	Schultze.
First 6 inches	·0041 second.	·0063 second.
Next 24 inches	·0014 ,,	·0013 ,,

Here it will be observed that, as the black powder burns more rapidly than Schultze, it drove the shot the first 6in. in much less time; but in the remaining four-fifths of the barrel (or 24in.) Schultze had a trifle the advantage.

Now let us see what the effect was on recoil. About the same time as above-mentioned Mr. Griffith tried some experiments with the same gun (a choked 12-bore of 7½lb. weight), in order to ascertain when the first movement of recoil began; and we now give the results of these experiments, in illustration of what is stated above. No obstruction whatever was offered to the backward motion of the gun, which was freely suspended; and the time was taken by chronograph from the first retrograde movement of the barrel to the issue of the shot from the muzzle. The times with successive shots were not so regular as could be wished (possibly owing to variations in strength of the caps), but, as they all pointed in the same direction, they may be taken as tolerably correct; and the averages show that the first movement indicated by the black powder was ·0015sec. before the shot reached the muzzle, whereas with Schultze it was ·0010sec. before; and, from the difference in time, it must be obvious that the movement with black occurred when its charge was at a greater distance from the muzzle than was that of Schultze. How far the shot had travelled when the recoil movement demonstrated itself may be estimated on comparing the times just mentioned with those previously given:

	Black.	Schultze.
Total time for 30in. barrel	·0055second.	·0076second.
Deduct recoil time	·0015 ,,	·0010 ,,
Time from fall of hammer	·0040 ,,	·0066 ,,

On comparing the last line of this small table with the first line of its predecessor, it will be seen that the first movement with black was indicated a short time before the shot had reached the 6in. point, while with Schultze there was a longer period after passing beyond that point. With the former, the shot was probably about 5in. from the breech, or 2½in. from the end of the cartridge case; with the latter the shot was probably some 9in. or 10in. from the breech.

[Another recoil experiment, with a gun freely suspended, to ascertain effect of inrush of air into a vacuum produced by an air-pump, is described in a subsequent article, page 203.]

The "Jump" of the Gun.

The differences in the commencement of the initial movement of recoil will doubtless have some influence on any divergencies produced on the line of flight of the projectiles. We do not believe, however, that, with the short range and wide spread of shot from a smooth-bore gun, any material effect will be produced; otherwise, when Schultze is used in the first barrel and black in the second, one might expect differences of result. Our impression is that such effects as "jump," or deviation to right or left, according to bend or cast-off of stock, are matters that mainly relate to rifles, where the frictional resistance is intense, rather than to the smooth-bore, where there is little to obstruct the movement of the shot when once it is set in motion.

Hence a recent proposition to shoot a Martini-Henry rifle with a cross-eyed stock, in order to test the effect of cast-off, seemed to us of little practical value, except in so far as it tested the individual peculiarities of different persons; and these peculiarities are now better met by Mr. Jones's "try gun." The trial of the rifle in question has not come off, as Mr. Greener requested that it should be returned to him for further experiment. This was accordingly done; and we do not see any necessity now for the trial being carried out. But we may say that, before sending back the rifle, we gave it a private trial with a result which supported Mr. Greener's contention that a stock with excessive cast-off would cause a rifle bullet to be thrown to the left—though it did not confirm the impression that an ordinary amount of cast-off would have this effect. On firing the rifle fitted to a stock having a cast-off of fully 3in., the bullets were thrown to the left—being placed at an average of about 2½in. from the centre of the bullseye, at a distance of 40 yards; consequently, the deviation in the 40 yards range was rather less than the amount of cast-off in the stock. With a stock which had half an inch cast-off (which is more than the usual amount for a person who has the full use of both eyes), there was no divergence whatever when the rifle was aimed exactly as before. This experiment seems to us clearly to demonstrate that the initial recoil in the gun has the effect of causing divergence where there is uneven resistance behind the barrel, but that the divergence is so small as not to be worth consideration in the shot gun.

But, although movements of this kind may have something to do with the production of what is known as "jump" in the rifle, there are other influences also at work, as will be seen by the following extract from a letter written to Mr. Walsh by Mr. Metford, C.E. (the inventor of the Metford rifle), and published in the second volume of "The Modern Sportsman's Gun and Rifle" (p. 225):

> When I began scientific rifle work, I felt that the proper thing would be to rig up a telescope sight, and that it would also be a proper thing to put its optical axis (in which line the cross-wires lay) absolutely parallel with the axis of bore. . . . With my telescope set to zero (or parallel with bore axis) I went to shoot at 25yds., speed 1400ft., therefore drop of bullet at 25yds. a trifle over ½in. Telescope was 1in. above bore axis, therefore I expected the bullet to strike 1½in. under centre of spot. Nothing of the sort happened; the bullet struck a considerable distance under. I at once thought I had made some stupid blunder, and reset the whole work again, but still the rifle did the same. I then fired the rifle laid flat to right, then the bullet struck nearly as much to left, and rather under. Again, I laid the rifle flat to left, and this reversed the strike, the bullet going to right and a little under. I then came to the conclusion that the barrel was curved, and that I had overlooked it; but I could not, on examination, see that it was at all curved. I then found this peculiarity attended all rifles, but with variation, and had nothing whatever to do with the bore *in re* its straightness. The point is, What is the cause? . . . . . My friend William Froude solved it, and showed clearly that it was entirely due to the mass of the stock being unsymmetrical with the mass of the barrel; and that the first thing the barrel would do, on explosion, would be that the muzzle would flip down, the barrel bending in a curve (this flip down would be dependent for its amount and velocity on the masses, and length, and stiffness, and charge of powder, &c.); and that eventually the whole motion would reverse itself, and the whole gun kick up; but that the bullet would be gone before the barrel had returned to its level and above it, unless the barrel was very stiff and short. . . . Rifles differ in amount of flip. . . . One of my rifles flips much the same amount whether I use quick or slow powder (the speed being equal). Another rifle I know is, on the contrary, curiously tender, and so tender that I can actually tell which powder is being used. Weights of powder and bullet affect it as well. You will see that there will be developed a lot of additions from the following cause: that the barrel, on the bullet passing the muzzle, may either be progressing down, or at its lowest, or returning. . . . It happens to be a convenient caper of the rifle, as it permits a much lower front sight for 100yds. ranges.

In a paper by Mr. Metford on Match Rifles, in the same volume, he says (page 198): "In rifles with the long fore-end, such as military rifles, the removing of the long fore-end increases the amount (of flip) considerably. A rifle, however, having an *extremely* short barrel, does not exhibit this anomaly."

Such instances as these, however, cannot be taken as the result of recoil, in its ordinary sense; but they serve to show that some of the phenomena of the "jump" may be due to other causes than the strictly backward motion of the gun, which moves very little before the shot is out of the muzzle, in comparison with what it does afterwards.

Relation between Velocity and Recoil.

In conclusion we may refer to a book which we quoted in our previous article—viz., the official "Text Book of Gunnery, 1887," one of the best combinations of theory and practice that has ever come into our hands. (It is issued by the Queen's Printers at the very moderate price of 4s.) At page 106 it says: "No very satisfactory relation between the velocity of the projectile and that of the gun and carriage on recoil has been determined."

Two formulæ are given, in both of which the weight of the powder is taken into consideration, and in the second the weight of powder is multiplied by C, "a constant determined by experiment." This formula, the author says, "gives fairly good practical results; but it must only be taken for what it is worth. No account is taken of several facts, or rather they are intended to be accounted for by the use of the constant C."

This constant, we take it, has to be ascertained by experiment with different guns and different varieties of powder; and it well deserves a big C, for being comprehensive enough to cover all the changes of circumstance that have to be met. The sum and substance of the whole affair thus seems to be, that nothing but practical experiment will settle what recoil really amounts to. P.—T.

RECOIL EXPERIMENTS WITH VACUUM IN THE GUN-BARREL.

Fine and Coarse Powders, &c.

(*Field*, April 13, 1889; Vol. 73, p. 503.)

A vacuum in the gunbarrel, after the firing of a charge, has often been suggested, and in the recent correspondence we have published on recoil it was revived, on the supposition that it is accountable for much of the back-thrust which takes place when the shot leaves the barrel. We did not believe in the vacuum, for several reasons, one of which was, that before a vacuum could be produced—indeed, as soon as ever the tension of the gases within the barrel should fall below the atmospheric pressure outside—air would begin to force an entry, without waiting for the escape of the rest of the gas; and this imprisoned gas, acting as a cushion, would thus tend to prevent any sudden blow being imparted by a rush of air down to the breech.

Anyone who has had experience in filling the tube of a barometer with mercury by the cold process, will know what effect a small bubble of air, when left in the tube, will have in breaking the force of a moving column of mercury, and how it will check the blow which should audibly announce that the operation is successful and the vacuum complete. And if so small a cushion of air suffices to curb the movement of a fluid body which is of more than ten thousand times its own specific gravity, one can hardly expect that the pressure of the atmosphere should so suddenly overmaster another gaseous body, of about equal density, as to produce the powerful effect known as the kick of the gun. However, not wishing the determination of the controversy to depend solely on theoretical reasons, we resolved to try what experiments would do towards effecting a settlement of the question.

Exhaustion of Air in the Barrel.

Having taken a single-barrel breechloader of 12-bore, drilled a very small hole through the barrel near the muzzle, and having also greased the cartridge case placed in the chamber, so as to prevent any accession of air, and likewise placed a greased disk of leather over the mouth of the gun, we exhausted the air in the barrel by means of an air-pump. When the mercury in the gauge of the air-pump showed, by its nearness in level to the barometric pressure, that a vacuum had been practically obtained (it being impossible to get an absolute vacuum by the air pump), the leather disk, to which a string was attached, was suddenly removed, and the air rushed in with a loud "pop."

Prior to applying the air-pump (which was worked up to the instant of removing the leather disk) the gun had been freely suspended, so that it could move backward on receiving the slightest impetus; but the effect of the inrush of air was so trifling that it did not suffice to overcome the *vis inertiæ* of the gun, which consequently showed no movement whatever.

This experiment was repeated several times, always with the same result; and, as here the gun weighed only 5½lb., the probability of producing any effect on a double-barrel gun of greater weight would be still more remote. As was pointed out by H. P. (see page 200), the

air contained in a 12-bore barrel would weigh barely 4grs.; and, seeing that a 7lb. gun weighs 49,000 grains, it can hardly be expected that 4grs. of air (even if it gave as effective a blow as a solid mass of equal weight) would impart much momentum to another body weighing more than 12,000 times as much as itself. And, now that the above-mentioned experiment has been tried, we think it may fairly be concluded that the sensation of the kick of a gun is not the result of a vacuum.

Effect of Air in Barrel on the Muzzle Velocity.

With the same gun we tried another experiment, for the purpose of ascertaining what effect any condensation of air during the passage of shot up the barrel, would have on the muzzle velocity of the shot. For this purpose, we thought it best to use a spherical ball, instead of a charge of loose shot, as it would enable more exact records to be obtained by chronograph. The gun was loaded with 3drs. of C. & H. No. 4 powder and a ball weighing 552 grs. Several rounds were fired from the gun in the ordinary way, and the velocities were taken by chronograph; and a similar series was fired, under like conditions, except that the air was exhausted from the barrel in the manner previously described. Accordingly, on the gun being discharged with the latter arrangement, the bullet had to drive the leather disk away from the muzzle before it could proceed to the first wire-screen of the chronograph, which was placed 30ft. from the gun, in order to prevent its being improperly affected by the discharge. This leather disk, being an inch in diameter, would doubtless offer more obstruction to the bullet than if it passed directly into the free atmosphere, and so the velocity recorded would be likely to be somewhat lower than what it would have been if this obstruction could have been dispensed with; but the records from the air-exhausted barrel were nevertheless rather higher than those from the gun when fired in its normal condition; the averages being, from the barrel in its ordinary state, 1181 ft.sec. muzzle velocity, and, with the air exhausted, 1192 ft.sec., or a fraction over 1 per cent. increase—not a very considerable amount, certainly, but still an appreciable quantity, especially when the fact next to be mentioned is taken into consideration.

[Another experiment, similar in character, but with a longer gun-barrel, is described in a subsequent article, reprinted on page 207.]

Effect of Vacuum upon Powder Pressures.

Another experiment made was to try what effect a vacuum would have on the explosive force of the gunpowder, as recorded by the crusher-gauge. The result went to show that, on an average of three shots with and without the vacuum, the powder gave about 2½ per cent. less pressure when the air in the barrel was exhausted. Hence, taking this diminution into consideration, it may be inferred that, had the bullets in both instances been propelled by the same amount of force, those fired from the exhausted barrel would probably have shown 3 or 4 per cent. higher velocity than the others, instead of merely 1 per cent.

It may further be concluded that the condensation of air in the 12-bore barrel, with the charge above stated, lessens the muzzle velocity by somewhere about 40 feet per second, or about one-thirtieth of its whole amount. The reduction of explosive force, under the circumstances here described, is doubtless due to the fact that, in the exhausted barrel, the expansion of the powder gases was only resisted by the weight of the bullet (about 1¼oz.), whereas, in the open barrel the bullet was backed up by the pressure of the atmosphere, which on the area of the 12-bore would be rather over 6lb. Of course, with the bullet, the cartridge case was not turned over, as it would have been with small shot.

Effect of Size of Powder Grain on Recoil.

A further experiment which we tried was to test the amount of recoil given by different powders under exactly the same conditions. A discussion on this subject took place in our columns some time ago, and a correspondent contended (see page 74), because greater recoil had been produced by slow-burning powders in artillery, that slow-burning powders must also give more recoil in sporting guns. Another correspondent thereupon said, as many others have said at various times, that his experience was opposed to this contention, for he had found his gun kick more with No. 2 than with coarse grain; but this elicited the rejoinder that "the fact that No. 2 black kicks more than coarse black of itself proves that the combustion of the former is slower than that of the latter when exploded in the bore of the gun." Happening to have by us some chronograph records proving the contrary, we accordingly published them (see page 75), and there the matter ended for the time being.

It seemed to us, however, that the results attendant on the use of slow-burning powders in big guns have not been produced merely by change of grain, but have been owing to the increase in the charge of powder and weight of projectile. A remarkable confirmation is given in Major Mackinlay's "Text Book of Gunnery, 1887," p. 107, which shows that the old 12-pounder gun weighed nearly 21cwt., and fired a 11½lb. shot with 1½lb. of powder, whereas the new 12-pounder gun weighs but 18cwt., and carries a 12½lb. shot propelled by 4lb. of powder. The proportions are almost exactly the same as if a sportsman changed his 7lb. gun for one of 6lb., at the same time increasing his shot-charge from 1⅛oz. to 1¼oz., and substituting 8drs. of coarse powder for 3drs. of fine grain. It is possible, under such circumstances, that an explanation of the increased amount of recoil might be found without attributing it merely to the slower combustion of the powder.

However, as we were experimentalising, we thought we would have the matter tested; and as Mr. W. P. Jones, of Birmingham, is possessed of two kinds of recoil registers—one being his own swinging recoil machine, and the other Mr. Walsh's spring-balance apparatus—we asked him to fire half a dozen shots with each, from the same gun, loaded in exactly the same way, except that the powder was to be altered after each dozen shots. Mr. Jones made use of a 12-gauge chokebore, weighing 7lb. 2oz., with 3drs. each of the black powders, or 42grs. of the nitro-compounds, and 1¼oz. of No. 6 chilled shot. The wads were, first, 11¾ Field wad, then ⅛in. felt of the same gauge, followed by a thin card of 12-bore, and another thin card over the shot; the cartridge cases were Kynoch's "perfectly gas-tight" maroon-coloured paper cases. Powder and shot were weighed throughout. The results of the half dozen shots with each machine, and the respective powders, were as follows:

Black Powders.	Mr. Walsh's Gauge.		Mr. Jones's Gauge.	
C. & H.		Average.		Average.
No. 6	40, 40, 40, 40, 40, 40 = 40		92, 92, 93, 92, 92, 92 =	92·1
No. 5	42, 40, 41, 41, 41, 42 = 41·1		99, 100, 101, 100, 101, 102 =	100·3
No. 4	43, 44, 43, 43, 43, 43 = 43·1		100, 100, 102, 101, 102, 101 =	101
No. 3	44, 44, 45, 45, 45, 44 = 44·3		110, 109, 110, 110, 110, 110 =	109·5
No. 2	48, 48, 48, 48, 48, 48 = 48		110, 111, 111, 110, 110, 110 =	110·2
No. 1	48, 47, 48, 48, 48, 49 = 48		110, 110, 110, 111, 110, 110 =	110·1
Nitro-Compounds:				
J. B.	34, 32, 32, 32, 36, 33 = 33·1		88, 86, 88, 84, 88, 86 =	86·4
E. C.	38, 36, 38, 39, 32, 37 = 36·4		90, 89, 90, 86, 90, 90 =	89·1
Schultze	41, 42, 42, 41, 41, 41 = 41·2		99, 100, 100, 100, 99, 100 =	99·3

The above results (obtained with the indicator starting from zero in each instance) vary with the respective scales, in much the same fashion as 35° Centigrade and 95° Fahrenheit serve to represent the same temperature. The two machines were also tried with the indicator starting from 60 in each case, a similar number of shots being fired; but the results were virtually the same in effect—the same order being maintained, with a difference in numbers—so that it is needless to occupy space with the full details. The No. 1 powder was not tried on the same day as No. 2 and the rest; while a variation in the condition of the atmosphere may possibly account for there not being a similar increase in recoil in that instance.

These records, which show an increase of recoil as the size of grain diminishes from No. 6 to No. 2, are, as it seems to us, only what might naturally be expected to result from the use of equal charges of these powders. As the grain diminishes in size, the rapidity of combustion is increased; more gas is evolved before motion can be imparted to the shot, the efforts of the gas to expand cause greater pressure, and this pressure drives on the shot more rapidly when it does move; while the backward motion of the gun is accelerated proportionately with the forward movement of the shot.

Grain of Powder and Quickness of Movement of Shot.

In order to show the difference of time taken by various powders in setting the shot in motion, and the difference in rate of progression up the barrel, we reproduce some of the particulars previously given with reference to experiments carried out by Mr. Griffith to ascertain the times taken by the respective powders in moving the shot from breech to muzzle. The figures given in the following table, in the column preceding the names of the powders, represent the times occupied, after the delivery of the blow on the cap and before any movement was indicated at 1 inch from the breech—*i.e.*, at the point where wads divide the powder and shot. As the recoil would not be affected by any duration of time prior to movement of the projectile, we keep this period distinct from the time of shot in motion, which is placed after the names of powders. In the column immediately following the powders is stated the time taken by the shot to move the first 5in. (*i.e.*, from 1in. to 6in.), while the next column indicates the corresponding mean velocity of the charge for the same distance; and if the motion be assumed to have been uniformly accelerated during this interval, the velocity at the 6in. point may be taken as double the mean speed.

The charge of shot (1½oz.) is almost exactly 100th part of the weight of a 7lb. gun; and so, while the shot is moving a given distance up the barrel, the gun would move back the 100th part of such distance, and attain 100th of the velocity of the shot. What the velocity of recoil would be with the respective powders when the shot reached the 6in. point, and what would be the corresponding energy of recoil with a 7lb. gun, will be indicated in the last two columns of the table:

Before moving. Sec.	Powders.	From 1in. to 6in. Sec.	Mean Velocity. Ft.sec.	Velocity of Recoil. Ft.sec.	Energy of Recoil. Ft.lb.
·00255 ...	No. 6 C. & H. ...	·00230 =	181 ...	3·62 =	1·43
·00209 ...	No. 4 ,, ...	·00199 =	209 ...	4·18 =	1·91
·00182 ...	No. 3 ,, ...	·00146 =	285 ...	5·70 =	3·54
·00158 ...	No. 2 ,, ...	·00106 =	393 ...	7·86 =	6·76
·00366 ...	Schultze ...	·00264 =	158 ...	3·16 =	1·09

As the energy of recoil imparted during the progress of the shot up the barrel—independently of any increase after the exit of the shot from the muzzle—would be somewhere about 16 ft.lb. (if weight and velocity of shot alone be taken into consideration), it will be seen how widely different a proportion accrued in the first 5in. with the various powders. In the remaining 2ft. the state of affairs was altered, as the powder which gave the greatest impulse at first, added least in acceleration towards the end; and in this way the nitro-compound, which was so slow in getting into action, increased more than any other its speed at the finish, and came out next in position to that powder (No. 2) which was finest in grain and consequently quickest in combustion.

This difference in the rate of combustion in powders is likely to be more felt upon the shoulder than indicated on a recoil gauge; for, even if the total amount of recoil were the same, the one would begin with a smartish blow at the outset, followed up by a not very marked increase, whereas the other would commence with a gentle push, and end with a quicker movement after the butt of the gun had been pressed firmly up to the shoulder.

Effect of Weight of Powder on Recoil.

Since the above was written, we have obtained, for the purpose of further illustrating this argument, the results of yet another experiment, carried out with the finest black powder made (No. 1), and the coarsest ordinarily used in shot guns (No. 6), besides a nitro-compound (Schultze). In order to get as nearly as possible the same velocity from the shot (1⅛oz. of No. 6), the quantity of black powder was varied, and, instead of using 3drs. (*i.e.*, 82grs.) of each, the No. 1 was reduced to 70grs., and the No. 6 raised to 86grs., or a difference of more than 20 per cent. Of Schultze, the ordinary charge of 42grs. was used. The wads were alike for all, except that an extra felt wad was put between shot and powder with No. 1, in order to avoid balling being produced by the rapid combustion of the fine-grain powder, as described at page 100. The recoil and velocity (*i.e.*, the mean velocity in a 40 yards range) with the respective powders, as taken by Messrs. Cogswell and Harrison's recoil machine and chronograph, were as follows:

Powders.	Recoil.	Average.	Velocity.	Average.
No. 6 C. & H., 86grs....	50, 50, 50	= 50	838, 844, 832	= 838
No. 1 ,, 70grs....	48, 46, 47	= 47	838, 828, 828	= 831
Schultze, 42grs....	44, 42, 43	= 43	857, 850, 854	= 854

It will have been seen from the results of Mr. Jones's experiments, given opposite, that when equal charges of fine and coarse powders were used, the former gave decidedly the greater amount of recoil; but here, where the charge was varied in order to obtain equal velocity, recoil increased with the weight of powder.

[In the reports of the 12, 16, and 20-bore trials of 1896 (see page 157), it will be seen that, where the barrels were short, more powder had to be used to impart equal velocity to the shot, and the recoil always increased with the additional weight of the powder.]

In the earlier part of this article, when alluding to equal charges of powder, we ignored the work done in expelling solid residue from the barrel; but now, with variations in weight of powder, we will touch on this point. Assuming the muzzle velocity imparted by the three powders to be equal—say, 1200 ft.sec.—the energy in the 1⅛oz. charge would be 1575 ft lb.; and a 7lb. gun being 100 times as heavy as the shot, the velocity of recoil would be 12 ft.sec. and its energy 15·75 ft.lb. But when the powder residue is added to the shot-charge, the weight is increased about 10grs. with Schultze, 40grs. with No. 1 black, and 50grs. with No. 6; hence instead of the 7lb. gun being 100 times the weight of the shot alone, the proportion is 93 with Schultze powder, 92 with No. 1 black, and 90 with No. 6. Consequently the velocity of recoil is increased; and its energy, instead of amounting to 15¾ ft.lb. with each, becomes about 16½ with Schultze, 18¾ with No. 1, and 19½ with No. 6. So this will account for some part of the differences recorded on the recoil gauge; and the greater outrush of gases, after barrel and shot part company, will doubtless ensure a further addition.

There is another fact, however, which yet remains to be told. When the 3½drs. of No. 6 powder was used in comparison with about 2½drs. of No. 1 grain, not a very great difference was shown either in the velocity of the shot or the *quantity* of recoil, yet there was a marked difference in the *quality* of the recoil as felt upon the shoulder. With the fine-grain powder it was a sharp, painful recoil of short duration; whereas the larger charge of No. 6 gave a recoil which had plenty of vigour in it, but was more in the nature of a push; and Schultze was much easier on the shoulder than either of the others, although the chronograph showed that it imparted the highest velocity to the shot.

[Some further experiments with different powders were tried in the next year, and are reported on in pages 208 and 209.]

P.—T.

VELOCITIES OF SHOT, AND RECOIL OF GUNS.

(*Field*, Oct. 4, 1890; Vol. 76, p. 523.)

Estimation of recoil, according to the formulæ ordinarily laid down in text-books on gunnery, is not a difficult matter, when the velocity and weight of the projectile are known, as well as the weight of the gun.

As an example of what we mean by ordinary formulæ, we give a quotation from a recent work issued by the Government as a text-book for the Army in general, and the Hythe School of Musketry in particular. It is entitled, "Treatise on Military Small Arms and Ammunition, 1888;" and at page 31 the following information is given on the subject:

Velocity and Energy of Recoil, how obtained.

The velocity of recoil and the energy of recoil are thus obtained:

Let W = weight of rifle in lbs.
V = velocity of recoil.
w = weight of bullet in lbs.
v = muzzle velocity of bullet.

Then, on firing, the momentum of the rifle is equal to the momentum of the bullet.

$$WV = wv$$

and $$V = \frac{wv}{W},$$

which gives the velocity of recoil.

We can then obtain the energy of recoil—

$$E = \frac{WV}{2g} \text{ ft. lbs.}$$

The mode of estimating recoil here applied to rifles is equally applicable to guns of smooth bore. Some of our readers, however, may not be familiar with the mathematical formulæ, and we will therefore briefly explain the process adopted.*

Let us suppose that 1⅛oz. of shot is propelled from a 7lb. gun with a muzzle velocity of 1200 feet per second. The weight of the gun is almost exactly 100 times as great as that of the shot charge; and so, according to the first portion of the above formulæ, the backward motion of the gun would have 100th part of the forward speed of the shot. In other words, the momentum of 7lb. with 12 ft.sec. velocity, is equal to the momentum of $\frac{1}{100}$ or ·07lb. with 1200 ft.sec. velocity.

But the last portion of the formulæ shows that, although the *momentum* of the shot is on an equality with that of the gun, the working power or *energy* of the two bodies is far from being alike. Momentum simply represents weight multiplied by velocity; whereas, in estimating energy, the velocity is "squared," the weight being multiplied by the *height* to which the body would be raised, if projected vertically—*i.e.*, supposing it to be unobstructed by air resistance. In such event, the product of the height (in feet) multiplied by the weight (in pounds) would give the amount of energy in foot-pounds.

In the case in point, the height to which the shot would rise (*in vacuo*), if projected vertically with a speed of 1200 ft.sec., would be ascertained by "squaring" the velocity, or multiplying 1200 by 1200,

* In the Government "Text-book of Gunnery" (Artillery), published in 1887, formulæ for estimating recoil are given, in which weight of powder is added to the weight of shot. We made calculations on this basis in connection with our present experiments; but the addition to theoretic recoil thus obtained is so small in comparison with the amount of actual work still left uncomputed, that it is needless to trouble our readers with the details.

and dividing by 64—*i.e.*, twice the accelerating force of gravity (omitting fractions). This process would show the height of lift of the shot to be 22,500ft.; and on multiplying this height by the weight of the charge (·07lb.), the energy of the shot-charge would be found to be 1575 ft.lb.

On the other hand, as the 7lb. gun would only move with a speed of 12 ft.sec., its amount of lift would be 12 + 12 + 64, or a height of 2·25 ft.; and, this height being multiplied by the weight of the 7lb. gun, the estimated energy of recoil would be 15·75 ft.lb.

So it will be seen that, with a gun weighing 100 times as much as the shot-charge, the energy of the gun's recoil would amount only to the 100th part of the energy of the shot at the time of its projection. And the difference in height of lift (supposing the gun were made to recoil vertically) would be still more marked—that of the shot being 100 × 100, or 10,000 times as much as that of the gun; hence, the respective height of lift would be 22,500ft. for the shot, and 2¼ft. for the gun.

The application of this principle to our new gun-rest (described on page 122) enables the amount of recoil to be measured in a very limited extent of space. If the recoil of the 7lb. gun alone had to be taken, it would move backwards several feet; but the gun-rest being connected with the gun, and their combined weight thus amounting to 35lb., the recoil, instead of extending over several feet, only covers a few inches; and the conversion from the one scale into the other is a mere matter of calculation—an inch of recoil representing rather over 14½ ft.lb.

Recoil begins before the Shot leaves the Barrel.

In some of the experiments we have carried out, the ordinary charge of 3drs. of powder with 1⅛oz. of No. 6 shot was used; but particulars with respect to these we defer for the present. In other instances, in order to get an idea of the effect of frictional resistance, we have used spherical ball in comparison with charges of small shot; and in such cases the shot charges have been regulated to exactly the same weight as the ball, viz., 525grs.

Before giving details of the experiments, we may mention (in reply to a question which has been raised on several occasions) that the recoil of the gun begins before the shot leaves the barrel. On the average of several rounds, with 3drs. of No. 2 powder and spherical ball, we found that, taking into consideration the interval of time which elapsed between the initial movement of recoil and the exit of the bullet from the muzzle, and allowing for the proportionate retardation due to the weight of the gun being increased by that of the rest—the backward movement of the gun was practically simultaneous with the ejection of the bullet from the cartridge case.

[In records of previous experiments, reprinted at page 202, we gave particulars of a somewhat similar character; but these were obtained with the old apparatus, now superseded. Here the records of recoil were taken with the new machine, of which a description is given at page 122.]

We may here say that we do not profess that experiments such as the one just alluded to are of an entirely novel character. The results we have obtained, on a small scale, with a sporting smooth-bore barrel and the ordinary Boulengé chronograph, are merely confirmatory of what was ascertained, on behalf of the French Government, some years since, with artillery of various sizes and much more elaborate apparatus. But the fact that the recoil of the gun does not originate with the exit of the shot from the muzzle, serves to show that formulæ based on muzzle velocity, and disregarding all antecedent work, can scarcely afford a satisfactory estimate of the energy of the gun's recoil. There is a large amount of frictional resistance to be overcome; and that resistance, as we propose to show, varies considerably with the size of shot used, and also with the variety of powder employed to propel the charge. As changes are made in these respects, so does the recoil vary; and not (as might be inferred from the formulæ quoted above) merely in accordance with the velocity exhibited by the projectiles on leaving the muzzle of the gun.

Effects of Ball and of Large and Small Shot.

Having, we think, said enough in the way of exordium, we will proceed to give the results of some experiments intended to elicit information respecting the influence of frictional resistance in the barrel as affecting the amount of recoil. The experiments were carried out with bullets and shot of various sizes—the charge of lead being equal in weight throughout, and the cartridge cases, wads, and circumstances of trial being exactly alike, except that the projectiles driven through the barrel differed in size.

The first series of which we shall give particulars was tried with No. 2 black powder. The velocities stated in the following records represent the observed or mean speed for a distance of five yards, as taken by the Boulengé chronograph. If we had had to deal with bullets only, we should have saved a considerable amount of trouble by using a longer range, and calculating the muzzle velocity from Professor Bashforth's tables; but, as the actual muzzle velocity of a charge of small shot cannot be ascertained by calculation, we adopted the course of trying the gun at so short a range that the shot-charge would traverse the distance with very little spread, and thus enable direct comparison to be made between its velocity and that of the bullet. Under the velocity of each of the six rounds is placed the amount of recoil registered in foot-pounds. The rounds are not given in the order in which they were fired, but in order of velocity, as that renders comparison more easy.

No. 2 Black Powder (3drs.), with Ball (525grs.):							Average.
Velocity	1216	1219	1222	1222	1226	1229	= 1222 ft.sec.
Recoil	*35·0*	*34·1*	*34·0*	*34·3*	*35·0*	*35·0*	*= 34·6 ft.lb.*

According to the formulæ quoted at the commencement of this article (page 205), the amount of recoil should be under 20 ft.lb., instead of over 34 ft.lb. This difference leaves a wide margin for the unrecognised work carried on in the barrel. Now we proceed to shot charges equal in weight to the ball:

Same Powder, with No. 2 Shot (525grs.):							Average.
Velocity	1087	1100	1103	1122	1148	1181	= 1120 ft.sec.
Recoil	*35·0*	*34·6*	*34·6*	*34·0*	*34·3*	*34·0*	*= 34·4 ft.lb.*

Here, it will be seen that, when the same gun and charge of powder which had been employed with the bullet are used with the same weight of large shot (No. 2), there is a considerable reduction in velocity—amounting to more than 8 per cent. According to the formulæ, the recoil should likewise fall 8 per cent., and this would cause a reduction of about 16 per cent. in energy of recoil; but the reduction in recoil was a mere bagatelle—only about half of 1 per cent.

We conclude that the powder performs about the same amount of work in both cases; but with the ball there is not much friction, as only its periphery touches the barrel. The shot, however, touches at many points; and the pellets being "jammed" together by the force behind them, the resulting amount of friction is very large in comparison with that of the ball, which is not "jammed up."

Same Powder, with No. 6 Shot (525grs.):							Average.
Velocity	1054	1061	1095	1100	1108	(1157)*	= 1080 ft.sec.
Recoil	*34·4*	*34·3*	*33·5*	*34·4*	*34·7*	*33·8*	*= 34·2 ft.lb.*

Here, the pellets of No. 6 being smaller than No. 2, the points of touch are more numerous, and friction is increased. There is a further reduction in velocity; and the recoil, as compared with that of the bullet, should fall off about 22 per cent.; but the actual reduction in recoil was only about 1 per cent. Now let us look at some still smaller shot.

Same Powder, with No. 8 Shot (525grs.):							Average.
Velocity	1030	1032	1066	1072	1074	1085	= 1060 ft.sec.
Recoil	*34·3*	*34·7*	*34·4*	*34·3*	*34·3*	*34·4*	*= 34·4 ft.lb.*

The friction being again increased, there is another falling off in the speed of the shot; and, taking velocity as the basis of estimation, there should be a corresponding reduction of recoil; but, on the contrary, the recoil is slightly increased as compared with No. 6, and stands on the same level as No. 2 shot, which had 60 ft.sec. higher velocity. Moreover, if the spherical bullet be taken as the basis of comparison, the reduction in velocity of the No. 8 shot should have been accompanied by the recoil being diminished to 26 ft.lb., instead of standing, as shown in the table, at 34·4 ft.lb.

We think it will be obvious, from the above records, that the increase of friction, resulting from the use of loose shot instead of solid ball, must lessen the amount of energy transferred to the shot, although the backward pressure which produces the gun's recoil is not varied to any great extent. With different powders, however, there are variations in different directions, as we propose to show in the next article.

(*Field*, October 11, 1890; Vol. 76, p. 557.)

Frictional resistance in the barrel, as indicated in our previous article on this subject, has a considerable influence on the amount of recoil in the gun as compared with the muzzle velocity of the shot; or, perhaps we ought rather to put it the reverse way, and say that friction considerably limits the velocity of the shot, in comparison with the force exerted by the powder, as demonstrated by the extent of the gun's recoil.

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* In this instance, the number placed between parenthesis is omitted from the average, for reasons which will be explained hereafter.

But friction is not alone in its influence on the comparative amount of shot-velocity and gun-recoil; for other means are also at work in producing the wide divergence observable between records obtained by practical experiment, and the theoretical estimates which are based upon formulæ such as were quoted in our last article (page 205).

Resistance of Air in the Barrel.

One of the experiments which we carried out in connection with this subject was for the purpose of ascertaining what amount of retardation in the projectile would be produced by the column of air that must naturally exist in the barrel under ordinary circumstances. To determine this, we had recourse to an air-pump; and, a small hole having been bored in the barrel, near to the muzzle, and a stout leather disk having been placed over the mouth of the gun, the pump was set to work, when the external pressure of the atmosphere upon the disk completely sealed the opening. The air in the barrel having thus been exhausted, the trigger was pulled, when the bullet drove away the leather disk, and afterwards struck the electric screen, five yards off. The velocity for that distance was taken by chronograph, and it was found that, on the average of four rounds, the speed of the bullet was increased by 41 ft.sec., as compared with similar rounds fired when the air in the barrel was not exhausted.

It might be assumed that the velocity would have been somewhat higher had the bullet not been obstructed by the leather disk, backed up by an atmospheric pressure of about 15lb. per square inch. Leaving that out of consideration, however, it may be said that the recorded addition to the velocity of the bullet should (according to theoretical formulæ) have been accompanied by about 7 per cent. increase in recoil; but this did not occur. In fact, there was a decrease of recoil—not much, it is true, but merely such as would correspond with a slight reduction in the amount of work, through the abstraction from the barrel of a column of air, which, although it serves to obstruct the passage of the shot, adds but a few grains to the weight of matter propelled from the gun.

We also ascertained by chronograph the amount of time which elapsed between the blow on the cap and the exit of the bullet from the muzzle, with and without a vacuum in the barrel. When the gun was fired under ordinary conditions, the time between cap and muzzle, with 3drs. of No. 2 black powder and spherical ball, averaged ·0042sec.; but when the air was exhausted from the barrel, the average time was reduced to ·0031sec.

We may add that the barrel was 34in. long—that length having been chosen with the view of investigating certain phenomena which we could not examine so fully as we wished with the 30in. barrels used in our experiments of last year. Then we tried a vacuum experiment with No. 4 powder and bullet in a 30in. barrel; and in this shorter tube, with the slower-burning powder, the difference in velocity was only 11 ft.sec. (see page 204), instead of 41 ft.sec. as mentioned above.

Recoil from Powder without Shot.

Another experiment in connection with this subject was to ascertain the amount of recoil when there was no bullet or shot in the barrel. According to the formulæ quoted in page 205, if there were no shot there should be no recoil; but it is a well-known fact that recoil is produced by the firing of blank cartridge, although it is small in comparison with that which results from the firing of a shotted gun. From the experiments carried out it appears that the recoil is not due merely to the weight of the powder and wads employed, but that it varies with the nature of the powder used and its rate of combustion.

For instance, we tried three samples of black powder, without shot or ball—the charge of each being 3drs., with wads, cartridge cases, and other conditions exactly alike throughout. With No. 2 grain the recoil with the unshotted gun amounted to rather over 6½ ft.lb. This was one-fifth of the full amount of recoil recorded on the scale of the recoil-gauge when the barrel was loaded with No. 2 powder and a bullet. With No. 4 grain—which is not so quick in combustion as No. 2—the recoil was rather lower, being about 6¼ ft.lb. With No. 6 grain—which burns with much less rapidity—the reduction of recoil was more marked, as the record was barely 5¼ ft.lb.

It would appear, therefore, that the amount of recoil is dependent in some degree upon the rate of speed with which the gases and other products of combustion of the powder are projected into the air that confronts the muzzle of the gun; for the three kinds of powder were equal in weight, and just the same in composition (all being Curtis and Harvey's T.S, or treble-strong), and the only difference was in the size of the grain, and consequent rate of combustion.

When there is a difference in the chemical composition of the powders, other complications are introduced with respect to recoil. Thus, the C. & H. brown powder gave a trifle less recoil than No. 6 black, with he unshotted gun, although imparting considerably higher velocity when a bullet or shot-charge was used. And with the nitro-compounds the results were even more remarkable. If the nitro-compounds (42grs.) had given about half as much recoil as the black powders (82grs.) fired under exactly the same conditions,* it would naturally be inferred that this was due to the charge of the former weighing only half as much as that of the latter; but whereas the black powders gave recoil records averaging about 6 ft.lb., the nitro-compounds simply shook the apparatus, without moving the gun back sufficiently to record even 1 ft.lb. This result is probably due, in some degree, to the slow combustion of the nitro-compounds; but more, we believe, to the less dense character of the products of combustion (see page 201). Light gases pass out of the barrel more readily than heavy gases, and their back-thrust on the breech of the gun would be correspondingly diminished.

Rate of Combustion of Powders.

Having alluded to the difference in rate of combustion of powders, we will here state the time, taken by chronograph, which elapsed between the blow on the cap and the exit of the bullet from the muzzle of the 34in. barrel. Eight kinds of powder were used, and the cartridge cases, wads, and other conditions were the same throughout. The following are the results:

WITH SPHERICAL BALL (525grs).

Black and Brown Powders.		Nitro-Compounds.	
No. 2 Black	·0042 sec.	Schultze	·0096 sec.
No. 4 ,,	·0052 ,,	E.C.	·0096 ,,
No. 6 ,,	·0076 ,,	J.B.	·0098 ,,
Brown (medium)	·0049 ,,	S.S.	·0082 ,,

We also tried a similar set of experiments with a charge of No. 6 shot; and it will be observed that the combustion of all the powders was quickened (though not in an equal degree) by the greater resistance of the shot-charge.

WITH No. 6 SHOT (525grs).

Black and Brown Powders.		Nitro-Compounds.	
No. 2 Black	·0032 sec.	Schultze	·0094 sec.
No. 4 ,,	·0045 ,,	E.C.	·0095 ,,
No. 6 ,,	·0074 ,,	J.B.	·0087 ,,
Brown (medium)	·0048 ,,	S.S.	·0076 ,,

The wads used in these experiments (as well as in all other cases unless stated to the contrary) were four tight *Field* wads, as they were found to develope the force of the powders more effectually than the ordinary felt wad and cards.

On referring to the tables hereafter given, it will be seen that the quickest burning powder, No. 2, showed the greatest reduction of velocity with the shot charges, as compared with the bullets—owing, as we believe, to the sudden and intense pressure "jamming" the pellets together, and thereby greatly increasing the amount of frictional resistance. On the other hand, with the slowest three of the nitro-compounds, the velocity of the shot-charges was in exces of that of the bullet, which did not offer sufficient resistance develope the force of these slowly-operating explosives.

In former experiments (see page 169), we used black powders made by three different firms—Messrs. Curtis and Harvey, Messrs. Hall and Son, and Messrs. Pigou, Wilks, and Laurence; and with the different sizes of grain we adopted the scale recommended in the C. & H. pamphlet—varying the weight of powder with the view of imparting equal velocity to the shot—so that the charges used were 76grs. of No. 2 powder; 82grs. of No. 4; 86grs. of No. 6; and 87grs. of brown. Under similar circumstances, however, it would have been impossible in the present experiments to determine how far the recoil exhibited might be due to the rate of combustion or other characteristics of the explosive, or how much might result from the extra quantity of powder. Hence on this occasion we resolved that the charge for black and brown powders should be 82grs. throughout; that the black powders should all be of the same brand, so as to avoid any difference in composition; and that for the nitro-compounds the charge should be 42grs. in all cases, notwithstanding that other charges might be recommended for ordinary purposes. By adopting this method of equal charges, the velocities hereafter given, as well

* The wads used, in order to fill up the cartridge case, in the absence of shot or bullet, were one tight *Field* wad, three felts, and a white card.

as the amount of recoil, will appear much higher with some powders than with others; but by representing in percentages the work respectively done in the form of recoil and velocity of projectiles, a more ready comparison can be made between the proportion of effective and ineffective work performed by the powders, than could possibly be obtained with charges varying in weight.

The E.C. powder used in the present experiments was the original or No. 1 variety. We tried No. 2 also, but the results were so close together that it seemed useless to continue both, so we retained that which is best known.

Work Done by Black and other Powders.

In the last article (p. 206) we gave the results of all the rounds fired with No. 2 black powder, with spherical ball and different sizes of shot. To give the whole of the powders in the same fashion would be likely to be tedious to the reader, besides occupying a considerable amount of space; and we therefore give only a summary of the averages of each powder—stating the muzzle velocity* of the shot, and the theoretic amount of recoil, based on that velocity, together with the actual amount recorded on the recoil gauge; while the last column, representing the percentage of work done, will show at a glance how the effective work diminishes with the increase of frictional resistance in the barrel.

We have not thought it necessary to continue here the records of No. 2 shot; and, having demonstrated the general principle, we propose to lessen the amount of work in future experiments by abandoning the use of No. 8, and confining the shot records to No. 6.

BLACK AND BROWN POWDERS.

LOADING.	Muzzle Velocity.	Amount of Recoil. Theoretic.	Amount of Recoil. Actual.	Percentage of Work. Effective.	Percentage of Work. Ineffective.
No. 2 Black,	Ft.sec.	Ft.lb.	Ft.lb.	%	%
with Bullet	1246	21·9	21·6	63	37
,, No. 6 shot	1102	17·1	34·2	50	50
,, No. 8 shot	1061	16·5	34·4	48	52
No. 4 Black,					
with Bullet	1129	18·1	32·5	55	45
,, No. 6 shot	1111	17·4	32·7	53	47
,, No. 8 shot	1109	17·3	33·1	52	48
No. 6 Black,					
with Bullet	1100	17·1	28·4	60	40
,, No. 6 shot	1033	15·4	29·0	53	47
,, No. 8 shot	1026	14·8	28·9	51	49
Brown Powder,					
with Bullet	1152	18·7	30·4	62	38
,, No. 6 shot	1104	17·2	29·9	58	42
,, No. 8 shot	1061	16·5	29·0	57	43

With the three kinds of black powder mentioned above, the amount of effective work performed—as shown by the velocity imparted to the shot—averaged but 54 per cent. of the total work indicated by the amount of recoil. The brown powder, with gases somewhat less dense than those of its black companions, shows a larger proportion of effective work, the average being 59 per cent. But the greatest difference is shown by the nitro-compounds in the following table. The products of combustion of these compounds are much lighter than those of the black powders, and the amount of effective work performed is higher, the general average rising to 68 per cent. Or, to put the matter in converse fashion, the non-effective work of the black powders is nearly one-half more than the non-effective of the nitro-compounds.

* In our previous article we said that the "muzzle velocity" of charges of loose shot could not be correctly calculated from Professor Bashforth's tables, and we therefore gave instead the mean or observed velocities directly obtained by chronograph in a range of five yards. For the purpose, however, of estimating the theoretical recoil, these observed velocities would hardly suffice, as the estimate would be too low. We have therefore here added 2 per cent. to the mean velocities in all instances, in order to obtain an approximately correct representation of the muzzle velocities. We found that this would be near about the amount of loss sustained by a flat-headed cylinder, which the charge practically resembled, for, whether it was bullet or shot, there was always a stout hard wad in front. Any inaccuracy that may exist will have the effect of representing the theoretic recoil as a trifle higher than it should be—an error on the right side, as we did not wish to understate it.

NITRO-COMPOUNDS.

LOADING.	Muzzle Velocity.	Amount of Recoil. Theoretic.	Amount of Recoil. Actual.	Percentage of Work. Effective.	Percentage of Work. Ineffective.
Schultze Powder,	Ft.sec.	Ft.lb.	Ft.lb.	%	%
with Bullet	1068	16·1	23·4	69	31
,, No. 6 shot	1133	18·1	28·2	64	36
,, No. 8 shot	1097	16·7	27·2	61	39
E.C. Powder,					
with Bullet	1058	15·8	22·2	71	29
,, No. 6 shot	1096	17·0	26·8	63	37
,, No. 8 shot	1084	16·6	26·8	62	38
J.B. Powder,					
with Bullet	1045	15·4	19·4	79	21
,, No. 6 shot	1090	16·7	24·8	68	32
,, No. 8 shot	1051	15·6	24·5	64	36
S.S. Powder,					
with Bullet	1200	20·3	26·1	78	22
,, No. 6 shot	1163	19·1	28·6	67	33
,, No. 8 shot	1137	18·2	28·6	64	36

The majority of sportsmen have, for a good many years past, come to the practical conclusion that the recoil of the nitro-compounds is much less than that of the black powders; but many military men adhere rigidly to the formulæ of the text-books, and contend that, if nitro powders give to shot the same velocity as black powders, they must also give an equal amount of recoil. An argument of this kind is found at page 32 of the "Treatise on Military Small Arms, 1888," which says: "Powders such as Schultze and Explosive Company powders are said to give as high a muzzle velocity as black powder without so much recoil; it is difficult to conceive how this can be the case, for if the bullet attains a certain muzzle energy, it ought to have a corresponding energy of recoil with the same rifle."

If gentlemen, who have hitherto looked upon this argument as conclusive, would consider the subject from another point of view, they might probably recognise the fact that the energy of recoil—as well with nitro-compounds as with black powders—always does attain such an amount as will correspond with the bullet's muzzle energy, *and something more*. This "something more," however, is in greater excess with black powders than with nitro-compounds; yet there is some line of correspondence between them. In a previous paragraph (p. 207, we said that, in an unshotted gun, the black powders gave about 6 ft.lb. of recoil, while the nitro-compounds gave none. Let us, then, add 6 ft.lb. to the records of actual recoil of nitro-compounds, and what do we find? Taking 28·2 ft.lb. as the recoil of Schultze with No. 6 shot (as shown in the last table), and adding 6 ft.lb. thereto, we get 34·2 ft.lb., which is the record of No. 2 black powder with No. 6 shot (as given in the preceding table). Again, adding 6 ft.lb. to the corresponding record of E.C powder, we get 32·8 ft.lb., that of No 4 black being 32·7 ft. lb.; and others approximate pretty closely, although not so exactly, as the velocities are wider apart. But, at all events, it seems pretty clear that this ability of the black powder gases to produce recoil in the unshotted gun, affords a clue to the general difference in the recoil records of the two sections of explosives.

(*Field*, Oct. 18, 1890; Vol. 76, p. 594.)

The particulars given, in the two preceding articles on this subject, have applied only to experiments with a 12-bore gun, 34in. in length. As previously stated, we selected a barrel of this unusual length because, in carrying out some former experiments with different kinds of powders, when the barrels were but 30in. long, we were unable to investigate certain phenomena so thoroughly as we desired to do. In those experiments (recorded in pp. 173 to 175). we gradually reduced the barrels from 30in. to 20in. in length; and we found that with some powders the greater portion of the velocity was imparted in the first half of the barrel, with comparatively little increase between 20in. and 30in.; whereas other powders exhibited only a low velocity in the first 20in., but made considerable addition thereto in the last 10in. It seemed, moreover, probable that there might have been even greater increase in some cases if the barrel had been more than 30in. long. In those experiments, however, the chronographic velocities were taken only with ball; and, wishing to ascertain what was the corresponding effect on small shot, we resolved to repeat some of the experiments with improved apparatus for

recording the velocities of shot-charges as well as bullets, and likewise for obtaining records of recoil simultaneously with records of speed as the barrel was reduced in length. For this purpose we had a longer barrel made, with the view of testing more completely the characteristics of the different explosives, and in the hope that we might be thereby enabled to trace, step by step, the amount of work done by each kind of powder—as well in producing recoil in the gun as in imparting velocity to the shot.

Having, in the last article, given a summary of results obtained with the 34in. barrel, when tried with eight kinds of powder, and projectiles of different dimensions, we will now proceed to give particulars of what has been done with the length reduced to 30in. The barrel was originally bored to as perfect a cylinder as the machinery could make it, and it has not been either relieved or choked in the slightest degree; consequently from stage to stage, in the reduction of its length, nothing whatever is done except the cutting off 4in. of the tube.

In these records we confine the particulars to the spherical ball (525grs.) and a charge of No. 6 shot of the same weight—wads and other conditions being exactly the same throughout. And instead of stating all the details included in the previous articles, we give only the three chief features, viz., muzzle velocity (estimated in the manner stated on page 208), the actual amount of recoil derived from the recoil-gauge records, and the percentage of effective work, calculated from the muzzle velocity and weight of projectile, as compared with the total work indicated by the recoil. In this condensed form, the results with bullet and with shot can be placed side by side, and the records of different lengths of barrel being ranged one under the other, a "birdseye view" of the whole is given in a form that admits of ready comparison. The following are the records with

BLACK AND BROWN POWDERS.

Powder and Barrel.	With Bullet.			With No. 6 Shot.		
	Muzzle Velocity.	Actual Recoil.	Effective Work.	Muzzle Velocity.	Actual Recoil.	Effective Work.
No. 2 Black (3drs.):	Ft.sec.	Ft.lb.	Percentage.	Ft.sec.	Ft.lb.	Percentage.
30in. barrel	1147	33·6	55 %	1034	33·7	50 %
34in. ,,	1246	34·6	63 %	1102	34·2	50 %
No. 4 Black (3drs.):						
30in. barrel	1120	31·5	56 %	1122	33·2	53 %
34in. ,,	1129	32·5	55 %	1111	32·7	53 %
No. 6 Black (3drs.):						
30in. barrel	1061	27·3	60 %	1043	27·7	55 %
34in. ,,	1100	28·4	60 %	1033	29·0	53 %
Brown (3drs.):						
30in. barrel	1056	28·4	55 %	984	28·9	47 %
34in. ,,	1152	30·4	62 %	1104	29·9	58 %

On examining these figures, it will be seen that with the spherical bullet, which gives comparatively little friction in the barrel, the increase of 4in. in the length of tube enabled a considerable increase of velocity to be made with No. 2 powder; but, although there was some increase of recoil, it by no means corresponded with the augmentation of speed in the projectile. Had the recoil increased according to the ratio laid down by text-book formulæ, the percentage of effective work would have stood at 55 % in both instances; but, instead of this, it rose to 63 % in the 34in. barrel. With the other two black powders, there was only a trifling increase in velocity of the bullet, and this was accompanied by an increase of recoil in very nearly the same ratio; so that the percentage of effective work remains almost the same. With the brown powder, however, the increase with the long barrel followed much on the same lines as No. 2 black, though in a somewhat less degree.

With the shot-charges, the black powders show very little difference of velocity arising from the alteration in length of barrel; the recoil records also keep in pretty close correspondence with the velocity, and the percentage of work varies only with No. 6. With the brown powder, however, there is a difference which seems rather remarkable.

With the nitro-powders there are other characteristics, as will be seen by reference to the next table:

NITRO-COMPOUNDS.

Powder and Barrel.	With Bullet.			With No. 6 Shot.		
	Muzzle Velocity.	Actual Recoil.	Effective Work.	Muzzle Velocity.	Actual Recoil.	Effective Work.
Schultze (4grs.):	Ft.sec.	Ft.lb.	Percentage.	Ft.sec.	Ft.lb.	Percentage.
30in. barrel	1099	25·4	62 %	1135	28·4	64 %
34in. ,,	1068	23·4	69 %	1132	28·2	64 %
E.C. Powder (4grs.):						
30in. barrel	1087	24·6	68 %	1097	28·7	59 %
34in. ,,	1058	22·2	71 %	1096	26·8	63 %
J.B. Powder (4grs.):						
30in. barrel	937	17·4	71 %	1046	23·4	66 %
34in. ,,	1045	19·4	79 %	1090	24·8	68 %
S.S. Powder (4grs.):						
30in. barrel	987	21·9	63 %	1035	25·1	60 %
34in. ,,	1200	26·1	78 %	1163	28·6	67 %

On glancing over these records of the nitro-compounds, it will be observed that, when the bullet was used, the performance of the 34in. barrel exhibited some disadvantage in comparison with the 30in. barrel, alike with Schultze and E.C., and recoil diminished as well as the velocity; whereas the reverse was the case with J.B. and S.S., both of which showed considerably greater velocity in the longer barrel, the recoil rising likewise.

When, however, the charge of No. 6 shot was used, under similar conditions, the results given by Schultze in the 30in. and 34in. barrel were nearly identical, both as regards velocity and recoil; and E.C. also kept very closely on the same lines, except that there was most recoil in the short barrel. On the other hand, J.B. again did best in the longer tube; while S.S. likewise, in the 34in. barrel, showed to much greater advantage than in that of 30in.

The above records with No. 6 shot, being taken with a charge of the same weight as the ball (525grs.) and four tight wads, the results would be likely to differ somewhat, both in velocity and recoil, from those given with 1½oz., or 492grs. We accordingly tried the ordinary charge and wads (viz., 11¼ black-and-pink wad on the powder, followed by a thick greased felt and white card, and another white card over the shot). The results were as follows:

BLACK AND BROWN POWDERS (3drs. and 1⅛oz.)

Powder and Barrel.	Muzzle Velocity.	Actual Recoil.	Effective Work.
No. 2 Black ... 30in. barrel	1136 ft.sec.	32·6 ft.lb.	50 %
,, 34in. ,,	1147 ,,	33·2 ,,	50 %
No. 4 Black ... 30in. barrel	1148 ft.sec.	31·6 ft.lb.	52 %
,, 34in. ,,	1122 ,,	31·8 ,,	50 %
No. 6 Black ... 30in. barrel	1050 ft.sec.	26·4 ft.lb.	52 %
,, 34in. ,,	1094 ,,	27·6 ,,	54 %
Brown ..... 30in. barrel	1000 ft.sec.	27·1 ft.lb.	46 %
,, 34in. ,,	1102 ,,	28·5 ,,	53 %

NITRO-COMPOUNDS (4grs. and 1⅛oz.)

Powder and Barrel.	Muzzle Velocity.	Actual Recoil.	Effective Work.
Schultze ..... 30in. barrel	1117 ft.sec.	26·7 ft.lb.	58 %
,, 34in. ,,	1119 ,,	25·1 ,,	62 %
E.C. Powder ... 30in. barrel	1091 ft.sec.	26·4 ft.lb.	56 %
,, 34in. ,,	1120 ,,	25·2 ,,	62 %
J.B. Powder ... 30in. barrel	1061 ft.sec.	23·3 ft.lb.	63 %
,, 34in. ,,	1101 ,,	22·0 ,,	69 %
S.S. Powder ... 30in. barrel	1093 ft.sec.	24·2 ft.lb.	62 %
,, 34in. ,,	1162 ,,	28·1 ,,	60 %

We shall now proceed to cut off 4in. more from the barrel, thereby reducing its length to 26in., and then it will again be tried with bullet and shot and the various powders, in order to ascertain once more how the velocity and recoil are affected by the alteration, and how the records compare with those which are printed above. [The subsequent experiments were carried out with two kinds of caps, as described on page 219.] P.—T.

PERCUSSION CAPS, AND EFFECTS ON GUNPOWDERS.

EXPERIMENTS WITH PERCUSSION CAPS.

(*Field*, June 20, 1891; Vol. 77, p. 911.)

A SHORT time ago we published some correspondence with reference to misfires in guns and variations in the strength of percussion caps, and we expressed our opinion that the faults complained of could not be due to the caps alone; for, although the failures occurred in some guns, they did not occur in others. When the caps gave perfectly satisfactory results with well-formed strikers and main-springs of good strength, but failed to do so with weak springs and worn or badly-shaped strikers, it seemed obvious that the blame should be attributed to the gun rather than to the caps. On the other hand, however, there was the fact that certain guns would perform well with caps made by one firm, but not with those of different manufacture; and if it could not fairly be said that the latter caps were badly made, it was yet pretty evident that they were not equally as sensitive as the former.

It is beyond question that many of the gunlocks now constructed have much weaker mainsprings than were employed in times past. To facilitate the opening of hammerless guns, the springs are made much lighter than they formerly were; besides which, wear-and-tear render locks and strikers less effective in course of time, and owners of guns do not always see that their modern guns require more frequent visits to the gunmaker to keep them up to the full standard of efficiency. Moreover, many a sportsman of limited means may buy a second-hand gun of apparently good condition, and be considerably annoyed by misfires arising from worn strikers, without discovering where the defect really lies, or being aware that a change in the caps may prove of service, without any alteration in the locks.

It seemed desirable, therefore, that further information should be obtained relative to the detonating compositions used in various kinds of caps, and the strength of the blow required to produce an explosion; and, a number of experiments having been carried out for the purpose of obtaining such information, we propose to lay the particulars before our readers, in the belief that the results will be of general interest. They show that there are considerable variations in the ingredients and proportions used in detonating compositions, as well as in the quantities that are inserted in caps issued by different manufacturers; besides which there are other circumstances that may also tend to limit the effectiveness of a blow of given strength. Hence it may happen that guns with thoroughly efficient locks will fire all caps with practically the same effect; whereas other guns, with less efficient locks, may fail to discharge caps of one make, yet may succeed with others of a more sensitive character.

Four kinds of caps were employed in these experiments, viz., (1 and 2) Eley's ordinary and large-sized caps; (3) Kynoch's caps, as made for their brass "perfect" as well as their paper cases (not with the long "legged" anvil formerly used in "perfects"); and (4) the large caps with "legged" anvils found in the so-called "High Life" cases, which are made in Belgium, but are a good deal used in this country, as they are recommended by some gunmakers as being especially advantageous with nitro powders—a claim which hardly seems to be borne out by the results of these experiments. The contents of the two varieties of Eley caps were analysed separately, but the results were so closely alike that we conclude the same composition is used for both kinds of caps; and we have accordingly given the average of the two analyses in stating the component parts of Eley's composition in the following table:

ANALYSES OF DIFFERENT CAP COMPOSITIONS.

	Eley's.	Kynoch's.	Belgian.
Fulminate of Mercury	42·14	39·30	42·94
Sulphide of Antimony	10·97	26·46	—
Chlorate of Potassium, and loss	27·89	34·24	52·31
Powdered Glass	19·00	—	—
Resinous Matter	—	—	4·75
Total	100·00	100·00	100·00

It will be observed that there is not very much difference in the proportion of fulminate of mercury contained in the three compositions; but in other respects there are considerable variations. Nearly one-fifth of Eley's composition consists of powdered glass, while in the other two kinds there is none. Powdered glass is also used in the Government caps made at Woolwich, and is said to have been introduced for the purpose of making the composition more sensitive; but the results of some of these experiments seem rather indicate that it has the opposite effect, as Eley's was less sensitive than Kynoch's composition, which contains no glass, but has more than double as much sulphide of antimony. In the Belgian caps there is no sulphide of antimony, but there is a largish quantity of resinous matter or varnish, used for fixing the composition and rendering it impervious to moisture. In the English caps, damp is kept out by means of a thin disk of tinfoil placed upon the surface of the detonating composition, but there appears also to be a small quantity of soluble matter (probably gum used for fixing purposes), which could not be separated and exactly estimated, and so is included in the analysis as "loss."

The quantity of composition found in Eley's ordinary caps averaged just about a quarter of a grain; and there was rather more than a third of a grain in the large caps made by the same firm. In Kynoch's, the average quantity was about midway between Eley's two. The Belgians contained rather more than half as much again as the ordinary Eley caps, and a third more than Kynoch's. The following table will show to what extent the quantity of detonating composition varied in caps of the same manufacture. The weights were taken to the nearest milligramme, and the variations are thus more readily comparable than by fractions of a grain. (A milligramme is equivalent to about the 64th part of an English grain.) The contents of each cap were weighed separately. Thus, 100 of Eley's large caps were emptied of their contents, and it was found that, out of that number, one cap contained 16 milligrammes of the detonating composition; three caps contained 17 milligrammes each; five contained 18 milligrammes; and so on as stated below. The full hundred, however, was not taken with every kind of cap; and we therefore give the percentages of each instead of the actual numbers, in order to make them more easy of comparison.

AMOUNT OF COMPOSITION IN DIFFERENT CAPS.

Quantity found. Milligrammes.	Eley's ordinary. Per cent.	Eley's large. Per cent.	Kynoch's. Per cent.	Belgian. Per cent.
11	3	—	—	—
12	3	—	—	—
13	8	—	—	—
14	11	—	—	—
15	11	—	2	—
16	21	1	8	—
17	18	3	10	—
18	12	5	10	—
19	8	4	22	—
20	3	12	20	4
21	2	11	13	0
22	—	14	8	4
23	—	10	5	16
24	—	21	2	12
25	—	9	—	20
26	—	2	—	20
27	—	6	—	4
28	—	2	—	8
29	—	—	—	4
30	—	—	—	4
31	—	—	—	4
Average in each cap	16·5 mill.	23·4 mill.	19·4 mill.	25·4 mill.

When the strength of the caps was tested by the distance at which the flash would ignite strands of guncotton, the results were not quite so regular as some records we have previously given. The average with Eley's ordinary caps was found to be 8·4in.; the shortest distance being 6in., and the longest 10in. With Eley's large caps the average was 12·3in.; the shortest being 9in., and the longest 16in. With Kynoch's the average was 9·2in.; the shortest being 7in., and the longest 11in. With the Belgians the average was 16·4in.; the shortest being 13in., and the longest 19in.

In order to ascertain the relative sensitiveness of the caps, when struck by a blow, a large number of experiments were made by dropping a 2oz. weight from different heights, with various alterations of condition, such as sharpening or blunting the anvils in the caps, or changing anvils from caps of one maker to those of another; for it was possible that such variations might give a clue as to whether the differences in sensitiveness depended upon the nature of the composition alone, or were influenced more or less by other conditions. In the first of these tests, the cap (with anvil inside, as usual) was placed upon a metal block, and the 2oz. weight carefully dropped upon it—the weight being suspended by means of a cotton thread, which was then burnt by the aid of a blowpipe, so as to secure a perfectly steady

fall. In these experiments the Belgian caps were not tried, as the legged anvils prevented their being tested in this way. Of the other kinds we give, in the following table, the number of caps fired, the highest and lowest fall, as well as the average extent of drop required to explode the caps; and we add also the amount of energy (in foot-pounds) corresponding with the average blow.

EXPERIMENTS WITH WEIGHTS DROPPED ON CAPS.

Anvils in usual state:	Eley's ordinary.	Eley's large.	Kynoch's.
Number of caps fired	30	30	40
Exploded at lowest drop	8·5 in.	10·0 in.	3·5 in.
,, ,, highest ,,	10·5 ,,	11·0 ,,	5·0 ,,
,, ,, average ,,	9·0 ,,	10·5 ,,	4·0 ,,
Energy of average blow	·094 ft.lb.	·109 ft.lb.	·042 ft.lb.
Anvils sharpened to knife-edge:			
Number of caps fired	15	12	6
Exploded at lowest drop	7·0 in.	8·0 in.	3·5 in.
,, ,, highest ,,	7·5 ,,	8·5 ,,	3·5 ,,
,, ,, average ,,	6·8 ,,	8·4 ,,	3·5 ,,
Energy of average blow	·071 ft.lb.	·087 ft.lb	·036 ft.lb.
Anvil sharpened to conical point:			
Number of caps fired	6	6	12
Exploded at lowest drop	8·5 in.	9·5 in.	4·0 in.
,, ,, highest ,,	9·5 ,,	10·0 ,,	5·5 ,,
,, ,, average ,,	9·1 ,,	9·7 ,,	4·5 ,,
Energy of average blow	·095 ft.lb.	·101 ft.lb	·047 ft.lb.
Anvil filed to a blunt head:			
Number of caps fired	10	30	13
Exploded at lowest drop	13·5 in.	16·5 in.	10·5 in.
,, ,, highest ,,	15·5 ,,	18·0 ,,	14·0 ,,
,, ,, average ,,	15·0 ,,	17·0 ,,	11·0 ,,
Energy of average blow	·156 ft.lb.	·177 ft.lb.	·115 ft.lb.

Throughout the whole of the experiments shown in the last table, Kynoch's caps proved much more sensitive than Eley's. The blow requisite to explode the Kynoch caps (with normal anvils) was less than half that required for the ordinary Eley caps; and for the large Eley caps a still stronger blow was necessary.

When some of Kynoch's anvils were transferred into Eley's ordinary caps, the latter were rendered a little more sensitive; but when the reverse method was tried—Eley's anvils being placed in the Kynoch cap—no difference in effect was noticeable.

In another series of experiments, the 2oz. weight was dropped upon the striker of the gun, and the caps (instead of standing on a metal block, as in the previous experiments) were in cartridge cases, placed in the gun in the usual way. Under these circumstances a much more forcible blow was required to explode the cap, as will be seen by the following particulars:

Anvils in usual state:	Eley's ordinary.	Eley's large.	Kynoch's.
Number of caps fired	15	25	15
Exploded at lowest drop	21 in.	20 in.	16 in.
,, ,, highest ,,	24 ,,	23 ,,	23 ,,
,, ,, average ,,	22 ,,	22 ,,	18 ,,
Energy of average blow	·229 ft.lb.	·229 ft.lb.	·187 ft.lb.

On comparing this table with its predecessor, it seems, at first sight, as though the Kynoch caps did not maintain the same degree of sensitiveness as before. But this apparent difference doubtless arises from the fact that the amount of force required to work the mechanism of the striker, when operating on the cartridge case, would virtually be a constant quantity, to be added to the force actually requisite to explode the cap. Thus, if we take, say, ·135 ft.lb., as the amount of force required to work the striker, and add it to ·094 ft.lb., the "energy of blow" required to explode the ordinary Eley cap when placed on the metal block, we get ·229 ft.lb., as stated in the last table. On doing the same with Eley's large caps we get ·244 ft.lb., instead of ·229 ft.lb.; and with Kynoch's we get ·177 ft.lb., instead of ·187 ft.lb.—which are not very great differences. The greatest difference occurs with the large Eley cap, which, instead of requiring more force than the ordinary cap, as appears by the previous experiment, is brought to the same level. This possibly may be due to the point of the striker acting more effectively on its large surface, when fired in the gun, than the flat weight did when dropped on the caps as they stood upon the metal block.

The blow that is given by the striker appears to be most effective when its head is rounded or hemispherical. On the striker being sharpened to a conical point (other conditions remaining the same as with the experiments stated in the last table) the drop requisite to explode the caps was increased to 27in. with Eley's (both kinds) and 25in. with Kynoch's—instead of 22in. and 18in. respectively, as mentioned above. And when the striker, instead of being round, was made quite blunt, or flat-headed, but of the same length as before, no ignition whatever was obtained, although the height of drop was increased to 40in.

As regards the shooting results, when powder and shot were employed, it may be said that (generally speaking, but not invariably) the larger the quantity of detonating composition in each kind of cap, the quicker was the ignition, as shown by the time which elapsed between the blow on the cap and exit of the shot from the muzzle. On the average, the time was shortest with the Belgian caps, viz., ·0053sec.; Kynoch's came next, ·0061sec.; Eley's large caps, ·0063sec.; and Eley's ordinary caps, ·0079sec.

The muzzle velocities, however, did not follow in the same order as the ignition. There was not much difference between them, but the lowest was the Belgian, viz., 1160 f.s.; Eley's ordinary giving 1167 f.s.; Eley's large caps, 1181 f.s.; and Kynoch's 1184 f.s.; so that the difference between the highest and the lowest was only about 2 per cent. Considering the large amount of detonating composition in the Belgian caps, it seems rather strange that the muzzle velocity should be lowest; but perhaps this may be due to the legged anvil breaking the force of the explosion, or to the resinous varnish acting as a check on the other constituents. When Eley's ordinary caps had the flash-hole enlarged, the time of ignition was quickened to ·0070sec.; but the muzzle velocity fell to 1159 f.s. The only powder used was Schultze.

There was nothing whatever to confirm the theory advanced by some of our correspondents, that a cap might explode so badly as to cause the gun to go off with a mere "fizz," and without force sufficient to kill a bird at twenty yards; nor, on the other hand, was there an indication that the largest quantity of fulminate occurring in the caps produced anything like detonation in the powder. When the cap in a cartridge, instead of being struck by the full force of the hammer, received but a very slight blow—only just sufficient to fire the cap—the time of ignition was a little lengthened, and the muzzle velocity fell off about 1 per cent.; the results, too, were not so regular as when there was a blow of full ordinary strength.

We need hardly say that, when powder and shot were used, the composition was not taken out of the caps and weighed before the cartridge was fired. The course adopted in such experiments was to weigh the cap with its contents complete before inserting it in the case, and to weigh the cap again after the cartridge had been fired. The difference between the weight of the cap in the fired and unfired condition was taken as representing the amount of detonating composition consumed.

As the operation of extracting detonating composition from caps is rather troublesome and risky, it will perhaps be worth while mentioning a "wrinkle" for the advantage of any of our readers who may have occasion to do such work. The best instrument for removing the composition was found to be a sharp needle. When a blunt-pointed tool of copper was used, explosions were very numerous; but when the needle was carefully used ignitions rarely occurred, and, if they did happen, the composition seemed merely to burn noiselessly away, as there was no explosion. Something of the same kind happened in the experiments with the dropped weight when the anvil was sharpened to a conical point. Several of the caps, fired under these circumstances, burned away without noise, instead of making the usual snap.

THE IGNITION OF GUNPOWDERS.

(*Field*, Sept. 12, 1896; Vol. 88, p. 429.)

THE art of gunnery has made immense strides during the present century; and in few respects has there been a greater change than in the mode of igniting the explosive; without which alteration many other improvements could never have been effected. Anyone who has not had some little experience of the "click—fizz—bang" of the old flint lock can hardly form a fair idea of the difference which has taken place since the publication of Colonel Hawker's celebrated work, "Instructions to Young Sportsmen in all that relates to Shooting."

At that time snap-shooting was practically non-existent. One had to pull the trigger and wait—the explosion coming on in what would nowadays appear to be the dim future. Nevertheless, slow as the process was, remarkably good results seem to have been obtained in those old times; though this was doubtless due, in great measure, to the birds being much less wild than they are at present. And to some of the old sportsmen the percussion caps were a considerable source of

trouble at first, as the gunners were disconcerted by the suddenness of the discharge, which spoilt their shooting.

A few years ago Mr J. Wolfe-Murray, of Cringletie, sent to us for trial an old percussion gun which had been altered from a flint-lock, and in the course of his letter he said: "I send you my first gun, with which I shot in 1827. My father, Lord Cringletie, a Scotch judge, gave it to me. He was one of the best shots of his day, and shot with a flint gun all his life. He had the gun converted to a detonator, but the suddenness of the fire startled him, and he could not shoot with it."

What was the rate of explosion in the flint gun as compared with the guns of the present day may be seen by the results of some experiments carried out about seven years since. Among the "guns of our ancestors" which we tried at the same time as Mr Wolfe-Murray's were several flint guns. One of the best among them we sent to Mr R. W. S. Griffith with a request that he would test it by his chronograph; and the following are particulars of the results, which were published in the *Field* of March 30, 1889:

We need hardly say that a very noticeable feature in the shooting of the guns with flint locks was the prolonged time that elapsed between the pull of the trigger and the departure of the shot from the barrel. Wishing to ascertain what proportion this time bears to that which elapses with the modern breechloader, we requested Mr Griffith, who had previously performed similar experiments with various descriptions of powder in his own breechloader, to undertake a like task with a flint-lock gun. . . . . The results of this trial went to show that there were considerable variations in successive shots—the time from the fall of the hammer (not touch of the trigger) varying from ·0750 sec. to ·1050 sec., with an average of ·0940 sec.; the powder used being No. 1, and the charge the same as in the general trial. With Mr Griffith's 12-bore breechloader, and the ordinary charge of 3drs. of powder and 1⅛oz. No. 6 shot, the time taken under similar conditions (*i.e.*, from fall of hammer to exit of shot), was, with C. & H. No. 2 T.S. powder, ·0039 sec.; with No. 3 powder, ·0046 sec.; with No. 4, ·0055 sec.; and with No. 6, ·0063 sec. So that, after the trigger of the flint gun was pulled, the shot would be fifteen times as long in getting out of the barrel as when No. 6 powder is fired in a modern breechloader; or seventeen times as long as No. 4 powder; or twenty times as long as No. 3; or twenty-four times as long as No. 2. Mr Griffith, in sending the results, fervently remarked: "I thank my stars we do not have to work with a flint lock."

Even within such a comparatively recent period as the time of the first *Field* gun trials, great improvements have been made in the ignition. The misfires which were then so prevalent are seldom heard of nowadays—at all events when black powders are used. With the nitro-compounds, however, matters are not nearly so satisfactory. These modern explosives are more liable to variations than their predecessor of "villainous saltpetre" fame; and each new candidate for public favour seems to add to the complication of results; so that cartridge manufacturers have now a far more difficult part to play than they had a decade or two ago. Then cartridge cases were supposed to be available for every kind of powder; and if results were not satisfactory, so much the worse for the explosives Nowadays the makers of new powders require special caps or cases to be made for their own products; and, if all does not go well, the cartridge manufacturers have a troublous time; while, if careless or ignorant loaders use, for one kind of nitro-compound, the cases which have been made for another variety that happens to require different ignition, the results may be very unpleasant for the owner and the maker of the gun; and it is not at all times easy to trace where the blame really lies.

There is one thing, however, which seems most essential with the nitro-compounds, and that is, that whatever may be the degrees of variation between the strength of igniting force required for the proper combustion of the respective powders, the caps that are made for any special explosive, or for any series of powders of a similar class, should be charged with the utmost possible regularity, as regards the quantity of detonating composition which is placed in individual caps of the same sample. Formerly, when black powders alone were in use, this was of comparatively small importance; and nowadays, when trials of black powders as well as nitro-compounds are made, the latter show themselves much more variable than the former as regards stress in the barrel, and differences in velocity and recoil. This is very obvious even when cartridge cases of the same make are used for all the different powders; and when the cases of another manufacturer are substituted, the change of caps affects some powders considerably more than it does others—probably owing to the difference in the chemical composition of the caps.

That the various powders are differently affected has been distinctly shown by experiments which we have carried out from time to time. For instance, in the *Field* of June 1, 1895, we published an article and diagrams showing the curves of pressure given by several varieties of powder, both black and nitros. The cartridges were loaded with charges which gave nearly the same average velocity, but there was more variation between the highest and lowest rounds with some powders than with others, as regards both velocity and pressure in the barrel. For example, we give here the pressures that were recorded by three varieties of black powder and four nitro-compounds, the charges being regulated so as to produce an average muzzle velocity of about 1220 feet per second, with 1⅛oz. of No. 6 shot. The difference of stress indicates the percentage of increase with the highest round beyond the pressure of the lowest round.

BREECH PRESSURES.

	Lowest round.	Highest round.	Difference of stress.
BLACK:			
No. 2	3·20 tons	3·34 tons	4%
No. 4	2·24 "	2·31 "	3%
No. 6	2·04 "	2·16 "	6%
NITRO-COMPOUNDS:			
Ballistite	2·58 tons	3·12 tons	21%
Cannonite	1·41 "	2·08 "	47%
Schultze	1·63 "	1·78 "	9%
Walsrode	1·83 "	2·40 "	31%

From these figures it will be obvious that the black powders were more regular in their performance than the nitro-compounds; while the irregularity in pressure was much more marked with some nitro powders than with others. (The three black powders and Schultze were loaded in cases that were exactly alike; while the three condensed powders had special cases, made by the same manufacturers as those used for black powder.) Now the irregularities we believe to be mainly due to variation in the caps, and not to variation in the powder. The explosives have their own peculiarities no doubt, and some require stronger caps than others; but it is extremely desirable that, whatever be the standard of strength which may be thought requisite for use with any particular powder, all the caps made for that powder should be as nearly as possible equal to one standard. But that they are not so in fact is manifest from the variations in velocity and recoil, as well as variations of stress in the barrel. The following particulars as to the muzzle velocity and energy of the 1⅛oz. charge of shot are derived from the same series of experiments as the pressures stated in the previous table:

	VELOCITIES.		ENERGY.		
	Lowest. Ft.sec.	Highest. Ft.sec.	Lowest. Ft.lb.	Highest. Ft.lb.	Difference in Energy.
BLACK:					
No. 2	1219	1244	1622	1690	4 %
No. 4	1214	1234	1610	1662	3½%
No. 6	1220	1244	1626	1693	4 %
NITRO-COMPOUNDS:					
Ballistite	1212	1264	1596	1745	9 %
Cannonite	1187	1244	1540	1690	10 %
Schultze	1164	1264	1490	1745	18 %
Walsrode	1196	1249	1568	1704	9 %

It will be observed that, in the first table, there was much less difference of stress in the barrel with Schultze than with either of the other nitro-compounds; whereas in the second table Schultze showed greater difference than the rest of the nitros as regards velocity and energy. This, in our opinion, was probably due to difference in strength of the caps. The stress recorded by crusher-gauge and the velocity recorded by chronograph cannot be taken simultaneously, and in the first set of experiments one powder may chance to have got the weaker or stronger caps, and in the second set of experiments this may have been reversed; and in a series limited to half a dozen rounds one powder may perhaps get a strong and a weak cap, whereas another powder may chance to have several regular caps in succession. It is not at all probable, however, that the variation could occur either in the strength of the powder or in the quantity used. The cartridges were not bought ready loaded, but with each kind of powder every charge was carefully weighed and loaded for the express purpose of the experiment, with the same kind of wads, same amount of turnover, and so on; and the only thing unknown was the strength of the caps in the respective cartridge cases. It is possible, therefore, that an unusually strong or weak cap may make a considerable difference in the record at the target, or cause a miss in the field when the sportsman feels certain that he was "dead on" his game. In the Schultze record, in the last table, five cartridges were fired in succession and averaged over 1230 ft.sec., but the sixth round was exactly 100 f.s. less in velocity than the highest of its predecessors, and this one round increased the proportion of variation from 8 per cent. with five rounds, to 18 per cent. with six.

Somewhat similar results are often shown in the amount of recoil; but in the experiments quoted above no recoil records were taken. We therefore give some from another series of experiments, carried out in the autumn of 1894. Here also the charges were regulated to give, on the average, an equal standard of velocity, and, as far as is known, the only cause for difference of results with successive rounds of the same powder must have been a variation in strength of the caps.

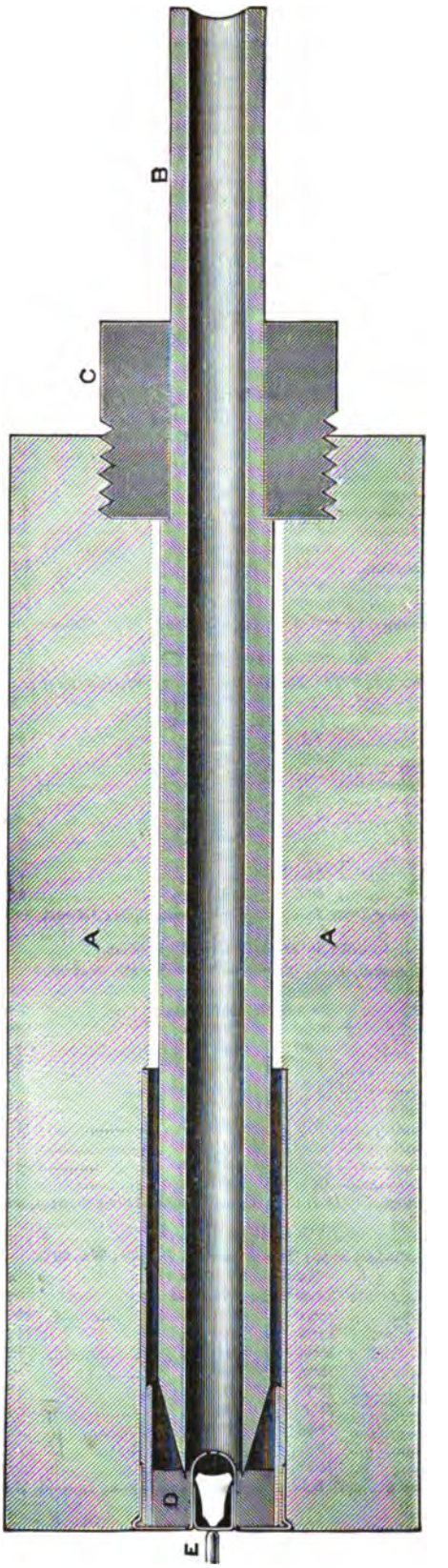
RECOIL COMPARISONS.

	Lowest.	Highest.	Difference.
BLACK POWDERS:			
No. 2	31·0 ft.lb.	31·5 ft.lb.	1½%
No. 4	34·5 "	35·2 "	2 %
NITRO-COMPOUNDS:			
Amberite	24·2 ft.lb.	27·0 ft.lb.	11 %
Cooppal	23·0 "	30·0 "	30 %
E.C.	26·6 "	29·5 "	10 %
Schultze	26·8 "	28·7 "	7 %
S.S.	23·6 "	28·1 "	19 %

Assuming, then, that the great irregularities in pressures, velocities, &c., given by smokeless powders, are mainly due to variations in strength of the caps, we thought it desirable to put the question beyond doubt by a new series of tests based upon the following considerations:—(1) In the course of manufacture of smokeless powders the various batches that are made are so intimately blended together in consecutive processes, that it is only reasonable to suppose that the finished product is fairly regular in strength. Of course those powders which give up and absorb moisture according to the state of the weather vary in strength to some extent; but it would be impracticable to remedy this defect by attempting to use caps of different strength to meet the change in the state of the weather. (2) It is no purpose of ours to come between the manufacturers of powders and the makers of caps. If a given powder requires a stronger cap than another, it is the business of the cap manufacturer to supply what is ordered; but in any case the caps of the same sample ought to be regular. The force necessary to properly ignite a given powder is, within close limits, a fixed quantity; and to this standard the cap manufacturer should endeavour to work. And we may add that regularity alone is the peg upon which we hang our trials and comments.

The object which we especially had in view was to test the strength of the caps themselves, independently of their special influence upon any particular variety or varieties of powder; and, after trying other methods, the course we ultimately adopted was to construct a small gun, and steel projectile, whereby to ascertain the propulsive force of the caps alone. The accompanying illustration will show the form of the gun, which consists of a barrel (B) eight inches in length and five-sixteenths of an inch in bore (or a trifle larger in diameter than the ·303 rifle). The breech end of the barrel—which is placed within the cartridge-case—is formed with a sharp edge, and by means of a screw arrangement (C) this is forced into the base (D) of the cartridge-case surrounding the cap-dome, so as to prevent any escape of gas. Thus the full force of the exploded cap is expended upon the projectile, and the difference in shape of the interior of the case can have no influence on the amount of force registered. The bullet weighs 47 grains, is made of hardened steel, and polished so that it is an exact sliding fit in the bore of the barrel. Its velocity is taken by chronograph, from a wire at the muzzle to a screen two yards distant, where the bullet is captured in readiness for the next round, and is used over and over again, without any wadding. Consequently the detonating composition within the cap is the sole propellant, and any variations in the strength of the caps are directly indicated by the velocity of the bullet. The results, however, are more effectively shown by the amount of "energy" exhibited, which may be ascertained thus: Square the velocity, multiply by the weight of the bullet, and divide by 64·4 (or twice the accelerating force of gravity).

We have tested various samples of caps, English and foreign, and here we arrange them in alphabetical order. Twenty cartridge cases of each kind were fired; and, taking the first batch in the following list, it will be seen that the amount of energy exhibited averaged 9·97 foot-pounds per cap; while the lowest was 8·10 ft.lb. and the highest was 11·06 ft.lb.; so that the strongest cap out of the twenty possessed rather more than 36 per cent. greater strength than the weakest. In comparison with some of the other samples this appears very regular. In order that the differences may be more readily followed, the highest and the lowest rounds are printed in *italics*. We cannot say that variations in the state of the atmosphere have any marked influence on the explosion of the caps, but we give the



SPECIAL GUN FOR TESTING THE STRENGTH OF CAPS.

records of barometer and thermometer in case anyone should wish to compare notes.

AMERICAN (U.M.C.) CASES.

(Barometer, 29·45; Thermometer—Dry 65°, Wet 64°.)

Velocity.	Energy.	Velocity.	Energy.
297 ft.sec.	9·18 ft.lb.	*326 ft.sec.*	*11·06 ft.lb.*
309 "	9·93 "	291 "	8·81 "
279 "	*8·10* "	287 "	8·57 "
308 "	9·55 "	313 "	10·19 "
283 "	8·27 "	316 "	10·39 "
310 "	10·00 "	301 "	9·43 "
306 "	9·74 "	289 "	8·69 "
301 "	9·43 "	314 "	10·26 "
310 "	10·00 "	284 "	8·39 "
303 "	9·55 "	308 "	9·87 "

(Average Energy, 9·97 ft.lb.; Highest round, 11·06; Lowest, 8·10.)

BELGIAN LARGE-CAP CASES.

(Barometer, 29·75; Thermometer—Dry 60°, Wet 58°.)

Velocity.	Energy.	Velocity.	Energy.
309 ft.sec.	9·93 ft.lb.	300 ft.sec.	9·36 ft.lb.
297 "	9·18 "	*345* "	*12·38* "
325 "	10·99 "	*345* "	*12·38* "
303 "	9·55 "	338 "	11·89 "
299 "	9·30 "	*287* "	*8·57* "
309 "	9·93 "	297 "	9·18 "
288 "	8·63 "	308 "	9·87 "
336 "	11·06 "	294 "	8·99 "
345 "	*12·38* "	324 "	10·22 "
321 "	10·72 "	339 "	11·96 "

(Average Energy, 10·36 ft.lb.; Highest round, 12·38; Lowest, 8·57.)

ELEY'S SMALL-CAP CASES.

(Barometer, 29·75; Thermometer—Dry 60°, Wet 58°.)

Velocity.	Energy.	Velocity.	Energy.
261 ft.sec.	7·09 ft.lb.	267 ft.sec.	7·42 ft.lb.
263 "	7·20 "	276 "	7·92 "
257 "	6·87 "	265 "	7·30 "
281 "	8·21 "	295 "	9·05 "
286 "	8·51 "	*226* "	*5·31* "
303 "	*9·55* "	283 "	8·33 "
298 "	9·24 "	259 "	6·98 "
294 "	8·99 "	284 "	8·39 "
278 "	8·04 "	268 "	7·47 "
250 "	6·50 "	254 "	6·71 "

(Average Energy, 7·75 ft.lb.; Highest round, 9·55; Lowest, 5·31.)

ELEY'S MEDIUM-CAP CASES.

(Barometer, 29·90; Thermometer—Dry 62°, Wet 62°.)

Velocity.	Energy.	Velocity.	Energy.
314 ft.sec.	10·26 ft.lb.	300 ft.sec.	9·36 ft.lb.
351 "	12·82 "	317 "	10·45 "
303 "	9·55 "	324 "	10·92 "
309 "	9·93 "	302 "	9·49 "
329 "	11·26 "	324 "	10·92 "
255 "	6·77 "	318 "	10·53 "
319 "	10·59 "	336 "	11·75 "
181 "	*3·41* "	*352* "	*12·89* "
339 "	11·96 "	308 "	9·87 "
326 "	11·06 "	297 "	9·18 "

(Average Energy, 10·15 ft.lb.; Highest round, 12·89; Lowest, 3·41.)

ELEY'S LARGE-CAP CASES.

(Barometer, 29·86; Thermometer—Dry 68°, Wet 62°.)

Velocity.	Energy.	Velocity.	Energy.
373 ft.sec.	14·47 ft.lb.	395 ft.sec.	16·23 ft.lb.
432 "	*19·42* "	420 "	18·35 "
377 "	14·79 "	356 "	13·19 "
384 "	15·34 "	404 "	16·98 "
353 "	12·96 "	*326* "	*11·06* "
406 "	17·15 "	377 "	14·79 "
402 "	16·81 "	381 "	15·10 "
404 "	16·98 "	375 "	14·63 "
404 "	16·98 "	408 "	17·32 "
404 "	16·98 "	386 "	15·50 "

(Average Energy, 15·75 ft.lb.; Highest round, 19·42; Lowest, 11·06.)

FRENCH CASES.

(Barometer, 29·59; Thermometer—Dry 65°, Wet 64°.)

Velocity.	Energy.	Velocity.	Energy.
375 ft.sec.	14·63 ft.lb.	362 ft.sec.	13·63 ft.lb.
351 "	12·82 "	337 "	11·82 "
373 "	14·47 "	352 "	12·89 "
321 "	*10·72* "	377 "	*14·79* "
339 "	11·96 "	359 "	13·41 "
336 "	13·94 "	366 "	13·94 "
349 "	12·67 "	366 "	13·94 "
349 "	12·67 "	370 "	14·24 "
349 "	12·67 "	348 "	12·60 "
349 "	12·67 "	351 "	12·82 "

(Average Energy, 13·16 ft.lb.; Highest round, 14·79; Lowest, 10·72.)

GERMAN CASES.

(Barometer, 29·50; Thermometer—Dry 63°, Wet 63°.)

Velocity.	Energy.	Velocity.	Energy.
267 ft.sec.	7·42 ft.lb.	277 ft.sec.	7·98 ft.lb.
189 "	*3·72* "	236 "	5·79 "
223 "	5·12 "	223 "	5·12 "
255 "	6·76 "	282 "	8·27 "
210 "	4·59 "	*290* "	*8·75* "
256 "	6·82 "	251 "	6·55 "
251 "	6·55 "	220 "	5·04 "
241 "	6·04 "	226 "	5·31 "
258 "	6·93 "	263 "	7·20 "
241 "	6·04 "	270 "	7·58 "

(Average Energy, 6·38 ft.lb.; Highest round, 8·75; Lowest, 3·72.)

JOYCE'S SMALL-CAP CASES.

(Barometer, 30·10; Thermometer—Dry 63°, Wet 60°.)

Velocity.	Energy.	Velocity.	Energy.
211 ft.sec.	4·63 ft.lb.	225 ft.sec.	5·26 ft.lb.
241 "	6·04 "	*287* "	*8·56* "
265 "	7·30 "	229 "	5·45 "
205 "	4·37 "	226 "	5·31 "
192 "	3·83 "	268 "	7·47 "
163 "	*2·76* "	217 "	4·89 "
202 "	4·24 "	271 "	7·64 "
232 "	5·59 "	223 "	5·17 "
231 "	5·55 "	186 "	3·59 "
260 "	7·03 "	208 "	4·50 "

(Average Energy, 5·46 ft.lb.; Highest round, 8·56; Lowest, 2·76.)

JOYCE'S MEDIUM-CAP CASES.

(Barometer, 29·93; Thermometer—Dry 70°, Wet 65°.)

Velocity.	Energy.	Velocity.	Energy.
248 ft.sec.	6·40 ft.lb.	261 ft.sec.	7·09 ft.lb.
186 "	3·59 "	199 "	4·11 "
239 "	5·45 "	249 "	6·45 "
248 "	6·14 "	217 "	4·90 "
198 "	3·87 "	242 "	6·09 "
232 "	5·12 "	247 "	6·35 "
195 "	3·95 "	*262* "	*7·14* "
169 "	*2·97* "	228 "	5·41 "
249 "	6·45 "	239 "	5·94 "
232 "	5·60 "	211 "	4·68 "

(Average Energy, 5·38 ft.lb.; Highest round, 7·14; Lowest, 2·97.)

JOYCE'S LARGE-CAP CASES (FOR "CANNONITE").

(Barometer, 30·12; Thermometer—Dry 61°, Wet 60°.)

Velocity.	Energy.	Velocity.	Energy.
239 ft.sec.	5·45 ft.lb.	258 ft.sec.	6·22 ft.lb.
186 "	*3·50* "	218 "	4·94 "
202 "	4·24 "	204 "	4·33 "
201 "	4·20 "	198 "	3·87 "
275 "	7·87 "	216 "	4·85 "
221 "	5·08 "	256 "	6·82 "
262 "	7·14 "	215 "	4·80 "
227 "	5·37 "	226 "	5·31 "
188 "	*3·67* "	248 "	6·40 "
197 "	4·08 "	206 "	4·41 "

(Average Energy, 5·41 ft.lb.; Highest round, 8·50; Lowest, 3·67.)

KYNOCH'S SMALL-CAP CASES.

(Barometer, 29·97; Thermometer—Dry 67°, Wet 63°.)

Velocity.		Energy.	Velocity.		Energy.
208 ft.sec.	4·29 ft.lb.		*229 ft.sec.*	*5·45 ft.lb.*	
163 "	2·76 "		205 "	4·37 "	
198 "	4·08 "		197 "	4·08 "	
202 "	4·24 "		209 "	4·54 "	
201 "	4·20 "		201 "	4·20 "	
185 "	3·56 "		*158* "	*2·60* "	
214 "	4·78 "		222 "	5·12 "	
188 "	3·67 "		186 "	3·59 "	
196 "	5·31 "		220 "	5·03 "	
174 "	3·15 "		213 "	4·72 "	

(Average Energy, 4·18 ft.lb.; Highest round, 5·45; Lowest, 2·60.)

KYNOCH'S MEDIUM-CAP CASES.

(Barometer—29·97; Thermometer—Dry 68°, Wet 59°.)

Velocity.		Energy.	Velocity.		Energy.
267 ft.sec.	7·42 ft.lb.		258 ft.sec.	6·92 ft.lb.	
256 "	6·82 "		244 "	6·19 "	
250 "	6·98 "		250 "	6·50 "	
271 "	7·64 "		232 "	5·59 "	
209 "	*4·54* "		253 "	6·66 "	
246 "	6·29 "		233 "	5·64 "	
236 "	5·79 "		263 "	7·20 "	
241 "	6·04 "		253 "	6·66 "	
235 "	5·74 "		*281* "	*8·21* "	
222 "	5·12 "		246 "	6·29 "	

(Average Energy, 6·41 ft.lb.; Highest round, 8·21; Lowest, 4·54.)

On looking over these records it will be observed that there is a great deal of variation in the strength of the caps. Occasionally there will be several rounds in succession that are admirably regular, and then there may be a sudden increase or decrease in strength, so that the highest of the twenty rounds may be double or three times the strength of the lowest in the same sample. Anyone may imagine for himself what difference of effect may be produced, in similar charges of powder, if one cartridge has injected into it a flash which is far stronger or weaker than the next. With black gunpowder this may not be a very great consideration, though it would suffice to account for the variations which occur in the records of successive rounds with the best of black powders. With these, however, the effects are tempered by the large amount of solid residue, as in black powders the gaseous products form only about 40 per cent. of the original weight of the charge, whereas the solid residue amounts to about 60 per cent., and thus dominates the exciting action of the cap composition. It is otherwise, however, with the nitro-compounds. In their case the gases form from 90 to more than 95 per cent. of the whole products of combustion; and the greater the proportion of the gaseous matter the greater is the influence produced by variations in the strength of the caps. The older forms of the nitro-compounds, such as Schultze, though more influenced than the black powders, are less so than the new condensed varieties which have greater claims to be designated "smokeless." These concentrated powders generally require a stronger impetus to excite them into action; and if that impetus be irregular or defective, the results are likely to be of greater consequence than they would be, not with black powders alone, but also with those nitros which contain a larger proportion of solid residue.

Several instances have occurred within the last year or two in which shot guns and rifles have been burst through the defective ignition of concentrated powders. Owing, it is supposed, to a weak cap, the powder-charge has been only partially burnt, yet sufficient force has been generated to push the shot out of the cartridge and leave it in the barrel. In some instances the shooter's attention has been attracted by the absence of a report, and on opening the gun and looking into the barrel he has found it blocked by the shot-charge. In others, where both triggers have been pulled, in rapid succession, the shooter has not noticed the absence of report, the empty cases have been ejected, and fresh cartridges have been inserted—the result being that when the trigger was again pulled a burst barrel ensued.

We think sufficient has been said to show that, in these days of concentrated powders, it is essential that the utmost possible amount of regularity should be secured in the manufacture of the caps. New explosives for military purposes are continually brought out and submitted to Government tests. The powder must not only be up to a given standard as regards velocity, but must also not vary more than a certain number of feet above or below that standard. When the new candidates for public favour fail to pass this test of regularity is it not probable that the defect may be less in the powder itself than in the different amount of strength in the caps by which it has been ignited?

P.—T.

(*Field*, April 17, 1897; Vol. 89, p. 581.)

In the preceding article we published the results of a long series of trials of percussion caps of British, American, and Continental manufacture. These trials brought to light what was suspected, but not actually known—viz., the excessive variations in the strength of caps.

We think we may fairly congratulate ourselves upon the fact that the trials above alluded to had the effect, among others, of placing Messrs Kynoch upon their mettle, with the result that their caps, as now sent to us, we have found more regular in their action than any others we have hitherto tried. We are not at liberty to divulge the means by which Messrs Kynoch have so much improved their fulminating compositions; but doubtless other manufacturers will soon follow their lead, as it is an open secret that since the publication of the article above referred to, they have been hard at work in endeavouring to obtain greater regularity in the strength of their caps.

The results of the trials are given below in tabular form, and we think Messrs Kynoch deserve great credit for having so successfully tackled this most difficult problem. The highest and lowest rounds, in the series of twenty, are indicated by *italics*, as in the previous report.

SAMPLE No. 1 (Case covered with brass ⅜ inch up from the base).

SMALL CAP.

Barometer, 29·70; Thermometer—Dry 45°, Wet 45°.

Velocity.		Energy.	Velocity.		Energy.
287 ft.sec.	8·57 ft.lb.		280 ft.sec.	8·15 ft.lb.	
321 "	*10·72* "		281 "	8·21 "	
309 "	9·93 "		301 "	9·43 "	
295 "	9·05 "		*264* "	*7·25* "	
295 "	9·05 "		292 "	8·67 "	
321 "	10·72 "		283 "	8·33 "	
290 "	8·15 "		318 "	10·52 "	
291 "	8·81 "		291 "	8·81 "	
304 "	9·61 "		295 "	8·45 "	
287 "	8·57 "		295 "	9·05 "	

Average energy, 9·02 ft.lb.; Highest round, 10·72; Lowest, 7·25.)

SAMPLE No. 2 (Case covered with brass for 1 inch from base).

SMALL CAP.

Velocity.		Energy.	Velocity.		Energy.
308 ft.sec.	9·87 ft.lb.		296 ft.sec.	9·24 ft.lb.	
301 "	9·43 "		*286* "	*8·50* "	
294 "	8·99 "		303 "	9·55 "	
317 "	*10·45* "		300 "	9·36 "	
290 "	8·75 "		288 "	8·63 "	
288 "	8·63 "		292 "	8·87 "	
301 "	9·43 "		313 "	10·19 "	
291 "	8·81 "		290 "	8·75 "	
296 "	8·50 "		307 "	9·30 "	
311 "	10·06 "		291 "	8·81 "	

(Average energy, 9·23 ft.lb.; Highest round, 10·45; Lowest, 8·50.)

SAMPLE No. 3 ("Grouse" case, with brass for 2½ inches). LARGE CAP.

Velocity.		Energy.	Velocity.		Energy.
258 ft.sec.	6·92 ft.lb.		273 ft.sec.	7·75 ft.lb.	
241 "	6·04 "		258 "	6·82 "	
270 "	7·58 "		259 "	6·98 "	
253 "	6·60 "		257 "	6·87 "	
233 "	5·60 "		241 "	6·04 "	
266 "	7·36 "		260 "	7·03 "	
279 "	*8·10* "		253 "	6·66 "	
227 "	*5·37* "		240 "	5·99 "	
245 "	6·24 "		273 "	7·75 "	
252 "	5·60 "		252 "	6·60 "	

(Average energy, 6·69 ft.lb.; Highest round, 8·10; Lowest, 5·37.)

At the trial of September last, of the twelve samples of caps then tested, the most regular results were given by some of American manufacture. We give the results then published, in comparison with those of Messrs Kynoch's present samples.

	Average. Ft.lb.	Highest. Ft.lb.	Lowest. Ft.lb.	*Difference* Ft.lb.
American (U.M.C.)	9·97	11·06	8·10	*2·96*
Kynoch's No. 1, small	9·02	10·72	7·25	*3·47*
" No. 2, small	9·23	10·45	8·50	*1·95*
" No. 3, large	6·69	8·10	5·37	*2·73*

With Kynoch's No. 2, the results are more regular than with any sample of caps we have ever tested. With the No. 3 sample (large caps), it is rather curious that the strength is less than with the smaller ones; and we can only suppose that this may be due to the quantity of the detonating composition not being increased although the cap is larger in size.

P.—T.

INFLUENCE OF "STRIKERS" ON THE EXPLOSION OF CAPS.

(*Field*, April 10, 1897; Vol. 89, p. 537.)

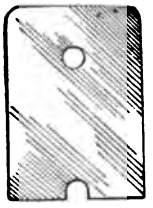
We have demonstrated, on various occasions, how greatly the explosive qualities of gunpowders—more especially the nitro-compounds—are dependent upon the caps by which they are ignited; and it is beyond question that, in various instances, where powders have been severely condemned by people who have used them, the fault has really been due to other causes.

For example, we have had complaints made to us of the badness of this or that explosive, and cartridges have been sent to us in order to demonstrate the supposed fact. But when we tried the disparaged cartridges in our own experimental gun (which is always kept in good working order), we have found the asserted fact to be a mere fiction; and, on requesting the complainant to forward his gun to us for examination, we have, in some instances, discovered that the strikers were so much worn that they required renewal. In others, however, the gun had been so badly made that the striker did not impinge on the central point of the cap; and, consequently, if the blow were struck on the side of the cap, instead of in the centre, there might be an indentation, but no explosion, because the top of the anvil, on which the striker should fall, might happen not to cross the cap at that particular point. If, however, the same cartridge were partially drawn out, given only a quarter turn, and then pushed back again, the position of the anvil being thus altered, the cartridge would explode perfectly on the trigger being again pulled.

Besides the guns whose strikers are too much worn, or badly centred, there are others which are defective, in a greater or less degree, through the strikers not being well shaped. Among the various articles on caps which have been published in the columns of the *Field* was one entitled "Experiments with Percussion Caps," which appeared in our issue of June 20, 1891; and lengthy particulars were there given, not only of the quantity of detonating composition found in different samples of caps, and the constituents contained therein, but also of the effects produced by varying the strength of the blow, and altering the shape of the striker. Now we are glad to lay before our readers a further addition to our knowledge, supplied by Mr R. W. S. Griffith, to whom we have been indebted, on so many previous occasions, for contributions which have elucidated obscure points connected with the use of guns and explosives.

Report on experiments with the striker in different conditions as to length and point in producing ignition of Schultze powder with small, medium, and large caps.

I started with a normal striker—that is, of length and shape to correspond exactly with the little gauge attached. I then sharpened it to a point; then shortened it blunt; then sharpened it at that length; then further reduced it in length, blunt, and again sharpened it; and so on, so as to use it in four different stages of length, each blunt and sharp, or in eight different conditions altogether. The hole in the gauge is the size of the striker; that is to say, the striker would easily pass through this small hole. At the bottom, the gauge shows the length which projects on the longest side when the striker is down. The full length of the striker, before shortening, showed one-tenth of an inch, and then was reduced, in the three successive shortenings, by a quarter—*i.e.*, one-fortieth of an inch each time—the different lengths therefore being four-fortieths, three-fortieths, two-fortieths, and one-fortieth of an inch respectively. These several conditions I will number thus:



1. Full length (0·100 inch) ..... blunt.
2. " " ..... sharp.
3. Three-quarter length (0·075 inch)..... blunt.
4. " " " ..... sharp.
5. Half length (0·050 inch) ..... blunt.
6. " " ..... sharp.
7. One-quarter length (0·025 inch)..... blunt.
8. " " " ..... sharp.

These were used with small, medium, large, and extra large cap cases, using the standard load of 42grs. and 1⅛oz. No. 6 shot, Field card wadding, and a thick card over the shot. The strength of the small caps being taken as 100 units, the medium gave 135, the large 160, and the extra large 180 units of strength.

Six shots were fired with each. I send you the highest, lowest, and average of each group; and the results were as follows:

	Cap.	Recoil. Ft.lb.	Time of Ignition. Highest.	Lowest.	Average.	Velocity. Ft.sec.
1.	Small	27·0	·0053	·0068	·0061	1229
	Medium	27·3	·0045	·0064	·0058	1226
	Large	27·2	·0045	·0057	·0054	1225
	Extra large	27·6	·0043	·0060	·0052	1230
2.	Small	27·2	·0050	·0075	·0072	1218
	Medium	27·4	·0054	·0073	·0069	1212
	Large	26·4	·0045	·0060	·0052	1210
	Extra large	27·2	·0045	·0059	·0051	1216
3.	Small	27·4	·0048	·0090	·0071	1204
	Medium	27·5	·0049	·0060	·0056	1208
	Large	27·5	·0047	·0064	·0052	1206
	Extra large	27·5	·0043	·0060	·0054	1210
4.	Small	25·8	·0048	·0190	·0105	1187
	Medium	26·4	·0047	·0084	·0069	1190
	Large	26·7	·0044	·0058	·0054	1184
	Extra large	27·0	·0046	·0060	·0057	1201
5.	Small	25·6	·0054	·0240	·0135	1190
	Medium	26·4	·0052	·0110	·0085	1189
	Large	26·5	·0048	·0098	·0080	1194
	Extra large	26·5	·0045	·0080	·0068	1203
6.	Small	25·5	·0059	·0250	·0150	1196
	Medium	26·6	·0058	·0138	·0110	1191
	Large	26·0	·0049	·0110	·0084	1186
	Extra large	26·2	·0054	·0088	·0076	1195 (2 misfires)
7.	Small	25·0	·0058	·0496	·0270	1196 (3 misfires)
	Medium	26·5	·0055	·0167	·0111	1205 (4 misfires)
	Large	26·5	·0045	·0637	·0265	1210 (3 misfires)
	Extra large	26·6	·0058	·0123	·0099	1204 (3 misfires)

8. Small, medium, large, and extra large, all gave misfires; none exploded.

The results go to show that the very short striker not only causes misfires, but increases the tendency to hang-fires, and that in every case, after the shortening of the striker is begun, the pointed striker is worse than the blunt one.

R. W. S. Griffith.

The above results not being easily comparable in the mass, we have taken the liberty of subdividing and analysing them, with the view of bringing out the various points more distinctly, and give the details at the close of this article.

Summing up the results generally, one may come to the conclusion that the more worn are the strikers—whether they have blunt points or sharp points—the worse are the results which they give. Besides which there is the fact that, as a rule, the sharp points seldom or never give quite such good results as the blunt ones, even when they are equal in length; while the more the sharp-points are worn, the greater is their loss in effectiveness. Moreover, it stands to reason that a sharp point will wear away more rapidly than a blunt one.

The fact should not be overlooked that, with strikers in thoroughly good condition, and springs of proper strength, misfires very seldom occur with caps as now made. Caps may not yet have reached the full regularity of ignition which we hope to see attained in the near future; but if sportsmen find they have an uncomfortable proportion of hang-fires and misfires, they would do well to ascertain whether there is any defect in the gun. Are the strikers of good shape and proper length? Are the mainsprings sufficiently strong to give an effective blow, or have they been weakened in order to make the gun open and close more easily?

In the experiments here mentioned the same gun was used throughout, and therefore the hang-fires and misfires could only be due to the difference in length and shape of the strikers, which serve to exaggerate any irregularities of strength in the caps. Here the cartridge cases were all made by the same firm (Messrs Eley), and only one kind of powder was used, *i.e.*, Schultze. The differences of result produced by the blunt and the sharp-pointed strikers are shown side by side on the next page.

SMALL CAPS, WITH BLUNT STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
1	·0053	·0068	*·0015*	1229	27·0
3	·0048	·0090	*·0042*	1204	27·4
5	·0054	·0240	*·0186*	1180	25·6
7	·0058	·0496	*·0438*	1196 [3]	25·0

It will be observed that, with small caps, and four lengths of strikers, there was not very much difference in the shortest times of ignition, which may be supposed to be produced by the best caps; but the more the strikers were reduced in length, the greater was the difference in times; indeed, with No. 7 one round took more than eightfold the time which was taken by another in effecting ignition, while three of the rounds missed fire completely.

MEDIUM CAPS, WITH BLUNT STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
1	·0045	·0064	*·0019*	1226	27·3
3	·0049	·0060	*·0011*	1208	27·5
5	·0052	·0110	*·0058*	1189	26·4
7	·0055	·0167	*·0112*	1205 [4]	26·5

The results with the medium caps were very similar in character to those with the small caps, except that there was not so wide a difference between the shortest and longest times. There were four misfires in this No. 7 lot.

LARGE CAPS, WITH BLUNT STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
1	·0045	·0057	*·0012*	1225	27·2
3	·0047	·0064	*·0017*	1206	27·5
5	·0048	·0098	*·0050*	1194	26·5
7	·0045	·0637	*·0592*	1210 [3]	26·5

With the large caps the shortest times kept very close together with all four blunt strikers, but the longest time with No. 7 was prodigious, and three of the rounds missed altogether.

EXTRA LARGE CAPS, WITH BLUNT STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
1	·0043	·0060	*·0017*	1230	27·6
3	·0043	·0060	*·0017*	1210	27·5
5	·0045	·0080	*·0035*	1203	26·5
7	·0058	·0123	*·0065*	1204 [3]	26·6

Again results were much the same as before, with regard to shortest times; but the divergences with the longest times were not so extreme as in previous instances; yet the increased strength of the cap did not prevent misfires with No. 7 striker.

The results of these experiments have led Mr Griffith to recommend, for use with Schultze powder, caps of a strength equal to the *medium* caps of Messrs Eley, as used above; and Messrs Kynoch's ordinary small caps are near about this strength. For other powders, it behoves the manufacturers of them to ascertain themselves what kind or strength of caps will best meet the requirements of their own products; for it is beyond question that the same caps will not answer equally well for all explosives, and a modification in the internal form of the cartridge case and the chemical nature of the detonating composition will produce different effects on different nitro-compounds. But one fact may be relied upon, viz., that whatever the caps and whatever the powders, the best results are not likely to be obtained if defective springs and strikers with bad points are used to ignite them.

Moral.—Use blunt points in preference to sharp ones, if you wish to get the best results out of your cartridges; and never let your guns go too long without sending them to the makers, with the view of getting the strikers restored to good working order. If the strikers are of proper length, they will produce tolerably good results even with the weaker caps; but when the strikers are not sufficiently long, average caps are likely to shoot weakly, while the weak caps will hang fire or not explode at all.

SMALL CAPS, WITH SHARP-POINTED STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
2	·0050	·0075	*·0025*	1218	27·2
4	·0048	·0190	*·0142*	1187	25·8
6	·0059	·0250	*·0191*	1196	25·5
8	All misfires.				

On examining the times of the sharp-pointed strikers, in comparison with those in the previous column, which resulted from strikers with blunt points, it will be seen that, although there is a close similarity as regards the shortest times, there is a rather wider margin with the more deferred ignitions, while the average times are longer. And, whereas No. 7 (with the blunt striker) had several misfires, No. 8 (with the sharp striker) misfired in every instance.

MEDIUM CAPS, WITH SHARP-POINTED STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
2	·0054	·0073	*·0019*	1212	27·4
4	·0047	·0084	*·0037*	1190	26·4
6	·0058	·0138	*·0080*	1191	26·6
8	All misfires.				

The medium caps, when tested with the sharp-pointed strikers, exhibited similar characteristics to those of the small caps; but the differences were not so wide apart; and, so far, resembled the results with medium caps in the previous column.

LARGE CAPS, WITH SHARP-POINTED STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
2	·0045	·0060	*·0015*	1210	26·4
4	·0044	·0058	*·0014*	1184	26·7
6	·0049	·0110	*·0061*	1186	26·0
8	All misfires.				

Once more we find the shortest times with sharp-pointed strikers very similar to those with the blunt strikers in the previous column; yet No. 8 had all misfires.

EXTRA LARGE CAPS, WITH SHARP-POINTED STRIKERS.

No.	Times of Ignition. Shortest.	Longest.	*Difference.*	Velocity. Ft.sec.	Recoil. Ft.lb.
2	·0045	·0059	*·0014*	1216	27·2
4	·0046	·0060	*·0014*	1201	27·0
6	·0054	·0088	*·0034*	1195 [2]	26·2
8	All misfires.				

With sharp-pointed strikers the extra large caps gave, in most respects, not quite such good results as with blunt strikers; and not only did all the rounds give misfires with No. 8, but there were like wise two with No. 6, in which the striker was not so short as No. 8.

EFFECT OF STRENGTH OF CAPS ON DIFFERENT KINDS OF POWDER.

(*Field*, Feb. 7, 1891; Vol. 77, p. 167.)

SOME rather curious results have been obtained in the course of experiments which we have lately carried out with caps of different strength, when used with black, brown, and nitro powders. About eighteen months since, when reporting on some trials we had then made with shortened barrels (see page 177), we gave particulars showing how much greater was the influence of strong caps on nitro compounds than on the ordinary black powders, and how differently the two classes of powders were affected by an alteration in the wads. When spherical ball was used in a smooth-bore with wads ordinarily employed with shot charges (*e.g.*, a tight *Field* wad over the powder, then thick greased felt, followed by a card between the felt and the shot), very good muzzle velocities were shown by black powders, but exceedingly poor ones by nitro compounds. These inefficient results with the latter were evidently due to the spherical ball not affording, in the smooth barrel, enough resistance to develope the force of the nitro explosives; for they produced much higher velocitie when

fired with shot charges, which offered greater resistance in the barrel; and so they did with ball likewise, when the friction was increased by the addition of three more *Field* wads in place of the greased felt—thus making four tight wads between powder and ball. Under these conditions, a considerable increase in muzzle velocity was exhibited by nitro compounds (when fired with ball), and by some more than others; whereas the black powders were only affected to a comparatively trifling extent.

In renewing our experiments, a few months ago, with the view of endeavouring to trace out some of the phenomena connected with recoil, we resolved to make a comparison of the effects produced by shot-charges of exactly the same weight as the spherical ball (525grs.), and loaded in the same fashion, viz., with four tight wads. We have accordingly tried both shot and ball, under similar conditions, with eight kinds of powder—taking by chronograph the interval of time which elapsed between the striking of the hammer on the cap and the departure of the shot from the gun; also the velocity of the shot on leaving the muzzle, and the amount of recoil exhibited; and we have also used the same charges with two kinds of caps, one stronger than the other:

In our experiments of 1889 we tried a few rounds with three kinds of caps—one being the ordinary caps contained in Eley's green cases, another kind being Eley's large sized caps, and the third being the caps contained in Kynoch's cases. Having found that the last-named were rather stronger than Eley's large caps, we employed Kynoch's for the experiments with strong caps in 1889, and have again had recourse to them in our present trials. We have tested the strength of the different caps in a manner similar to that which was adopted by Mr Walsh in his experiments with nitro powders—that is to say, by employing a long brass tube, cut half-way through by fine traverse saw-cuts, an inch apart, wherein are placed threads or filaments of guncotton, which thus stretch across the centre of the bore. On the tube being put into the barrel of the gun, one extremity enters an empty cartridge-case in the chamber, and consequently the tube surrounds the cap-hole; on the trigger being pulled, the flash from the cap ignites the guncotton (provided it is not placed too far away), and the distance of the burnt thread from the breech serves to indicate the strength of the cap.

There are two methods of using this test—one by putting a thread into every saw-cut, and counting how many threads are burned; the other is by using only one thread at a time, and repeating the operation by increasing the distance inch by inch until the flash fails to ignite the cotton. We prefer the latter, although troublesome, as giving more regular results; for with the former, the ignition appears to be extended from thread to thread by the fired cotton, instead of by the cap alone. For instance, the Kynoch cap burned from sixteen to nineteen threads when all the notches were filled; whereas the same cap would regularly burn a single thread placed in the 11in. notch, but not ignite one placed at 12in. from the breech. The ordinary Eley cap would vary from eleven to fourteen threads, when they were placed in succession, but would regularly burn a single thread at 9in., but not ignite one at 10in.; so we may conclude that the Kynoch cap is rather more than 20 per cent. stronger than that of the ordinary Eley case. The large Eley cap was intermediate between the other two.

The following table states the results of experiments with ball and shot-charge of equal weight, with similar conditions of loading—Eley's cases being used for the "ordinary cap," and Kynoch's for the "strong cap." We first give the "time" from the blow on the cap to the exit of the shot from the muzzle; but, as some readers may find "speed" more comprehensible than small fractions of a second, we also add the equivalent mean velocity for the distance from breech to muzzle, viz., 28in., allowing 2in. for the space from the cap to the shot-wad, which, of course, first leaves the barrel and breaks the wire of the chronograph. The "muzzle velocity" is estimated from a range of 5 yards, as explained in a previous article (page 208). The muzzle velocity is not obtained from the same round as the time from cap to muzzle, but is taken separately. The figures given in both are the average of six rounds each; and the word "increase" or "decrease" relates to the variation produced by the strong cap.

VELOCITIES WITH BLACK AND BROWN POWDERS.

Kind of Powder and Caps.	Spherical Ball (525grs.)			No. 6 Shot (525grs.)		
	Cap to Muzzle.		Velocity at the Muzzle.	Cap to Muzzle.		Velocity at the Muzzle.
	Time. Sec.	Speed. Ft.sec.	Ft.sec.	Time. Sec.	Speed. Ft.sec.	Ft.sec.
No. 2 Black:						
Ordinary cap.....	·0040	= 583	1147	·0041	= 569	1094
Strong ,, ...	·0037	= 631	1174	·0040	= 583	1136
		Increase, 2%			Increase, 4%	
No. 4 Black:						
Ordinary cap.....	·0049	= 476	1120	·0054	= 432	1092
Strong ,, ...	·0040	= 531	1118	·0046	= 507	1104
		Virtually equal.			Increase, 1%	
No. 6 Black:						
Ordinary cap.....	·0067	= 348	1081	·0073	= 319	1945
Strong ,, ...	·0048	= 486	1015	·0051	= 458	982
		Decrease, 6%			*Decrease*, 6%	
Brown (Medium):						
Ordinary cap.....	·0051	= 458	1056	·0060	= 389	984
Strong ,, ...	·0044	= 531	1065	·0047	= 496	1042
		Increase, 1%			Increase, 6%	

On looking over these figures it will be observed that the strong cap always shortened the time in the barrel; and in the majority of cases it increased the muzzle velocity also, both with ball and shot-charges, though not to a very material extent. A remarkable exception, however, occurred with No. 6 black powder, which showed a considerable falling off in muzzle velocity through the use of the stronger cap. At first we were inclined to think there was some error, and had experiments repeated; but these only confirmed the results that had been previously obtained.

The next table shows the records made with four nitro-compounds; and the reader will observe how different are the effects of the strong cap on some of these powders as compared with others.

VELOCITIES WITH NITRO-COMPOUNDS.

Kind of Powder and Caps.	Spherical Ball (525grs.)			No. 6 Shot (525grs.)		
	Cap to Muzzle.		Velocity at the Muzzle.	Cap to Muzzle.		Velocity at the Muzzle.
	Time. Sec.	Speed. Ft.sec.	Ft.sec.	Time. Sec.	Speed. Ft.sec.	Ft.sec.
Schultze:						
Ordinary cap.....	·0080	= 292	1099	·0066	= 272	1135
Strong ,, ...	·0050	= 467	1122	·0053	= 440	1133
		Increase, 2%			Virtually equal.	
E.C.:						
Ordinary cap.....	·0061	= 288	1087	·0067	= 269	1097
Strong ,, ...	·0053	= 440	1107	·0057	= 409	1102
		Increase, 2%			Virtually equal.	
J.B.:						
Ordinary cap.....	·0079	= 295	937	·0097	= 240	1046
Strong ,, ...	·0059	= 395	1130	·0056	= 416	1094
		Increase, 20%			Increase, 4%	
S.S.:						
Ordinary cap.....	·0074	= 315	987	·0099	= 236	1035
Strong ,, ...	·0052	= 449	1154	·0054	= 432	1178
		Increase, 17%			Increase, 14%	

On comparing this table with its predecessor, it will be seen that, with all four of the nitro-compounds, the movement of the shot within the barrel was very much quickened by the use of strong caps. Nevertheless, its effect on the muzzle velocity with the first two powders in this table was comparatively small; not very different, indeed, from that occurring with the first two of the black powders. But with the latter two nitro-compounds the strong cap made a marked increase in the muzzle velocity, which was thereby raised nearly 200 ft.sec. with the bullet, and to a very material though smaller extent with the shot-charge.

It may perhaps be remembered by those who have read the articles descriptive of our previous experiments, that the two nitro-compounds which here exhibit so considerable an increase in muzzle velocity, as a consequence of the employment of the strong cap, are the same powders which showed so large a falling-off in muzzle velocity when the barrel of our experimental gun was reduced in length from 34in. to 30in. For further particulars on this point reference must be made to our article in the *Field* of Oct. 18, 1890 (see page 208), but we may here briefly state that the influence of the extra 4in. of barrel on these two explosives was very similar to the effect now produced on them by the stronger cap. We think, therefore, the inference may naturally be drawn that the two nitro-compounds here alluded to are slow in the development of their propulsive powers, and do not exhibit their full capabilities when fired with the ordinary cap in barrels of ordinary length. When, however, means are provided for a more complete combustion of the powder within the gun—either by increasing the length of the barrel, or quickening the decomposition of the powder by means of a stronger fulminate—there is a fuller

development of the propulsive force, and a consequent increase in the muzzle velocity of the shot.

The fact should be borne in mind, however, that the two nitro powders which stand at the top of the table do not exhibit the same effect as the two at the bottom. The first two appear practically to attain their full degree of propulsion when employed with the ordinary cap in a 30in. barrel. The longer barrel did not enable them to show any increase of muzzle velocity; on the contrary, there was a little diminution, which probably was due to the resistance in the extra length of barrel more than counterbalancing the force that still remained in the powder gases. And a somewhat similar result is now shown with the strong cap, when used with the first two of the nitro-compounds. Its employment with the shot-charge did not produce an increase of velocity; and with the bullet, which is less affected by friction, the increase was so small as to be immaterial. Possibly, in future experiments, as we shorten the barrel from stage to stage, we may be able to ascertain at what point of the barrel the maximum muzzle velocity is produced with each of the various powders and the two kinds of caps.

We may add, that in the above tables the times and velocities occasionally differ somewhat from those given in previous articles. We have on many occasions thought it desirable to repeat experiments, and we find that the results frequently vary with the temperature and other conditions of the atmosphere; and we prefer, whenever it is possible, to make comparisons between results obtained on the same day and under similarity of conditions. P.—T.

EFFECT OF STRONG CAPS ON VELOCITY, RECOIL, AND PRESSURES.

(*Field*, Sept. 12, 1891; Vol. 78, p. 414.)

In a previous article (see page 177) we published lengthy details of a number of experiments which showed the variations in velocity and recoil produced by different powders, when fired from barrels of different length. These experiments were carried out with Eley's ordinary caps. When, however, we published the first of the records, made with the 34in. and 30in. barrel, a correspondent wrote to suggest that we should extend the experiments, so as to include strong caps in the trials. We adopted this suggestion, and now proceed to give the results. The caps, or rather the cartridge cases (for new ones, already capped, were used throughout) were Eley's best quality, with their ordinary caps, and Kynoch's paper cases known as the "Grouse" cartridge. The difference in the strength and sensitiveness of these caps was shown in an article published in the *Field* of June 20, 1891 (here reprinted at page 210).

As the barrel in which the experiments were tried had already been cut down to 30in. at the time we received the suggestion, no experiments with strong caps were made with the 34in. barrel; but from 30in. to 10in. they were carried out under similar conditions to those under which the ordinary caps were tried—both being fired on the same day. We shall not tabulate the results so fully as we did those on August 29, but, in order to facilitate comparison, shall so compress them as to place the two sets of records side by side.

On comparing the opposite sides of the foregoing table, it will be observed that the general effects produced by the strong caps on black powders did not differ to any very wide extent from those resulting from the use of the ordinary caps. With No. 2 and No. 4 grain the velocity was moderately increased when strong caps were used. But a more remarkable circumstance was that with No. 6, in the 30in. barrel, the velocity fell off to a much greater extent than it had been increased with the powders of finer grain; and the recoil was also diminished, though not in like proportion. When we first compared the results we thought there must be some error; but we could not discover one. On referring, however, to some records of the pressures of the respective powders tried by means of the crusher-gauge, we found there was a considerable decrease in the force exerted in the barrel by this powder when it was fired by the strong caps; and so the records obtained by chronograph and recoil-gauge were confirmed. It nevertheless seems rather strange that there were not corresponding differences with the shortened barrel.

With the nitro-compounds, the use of the strong cap always produced an increase in velocity, whatever the length of barrel; but there was a difference in the extent to which the respective powders were influenced. Schultze increased in velocity about 20 f.s., E.C. about 30 f.s., and S.S. about 40 f.s.; but, although there was an increase of recoil, it did not, as a rule, correspond with the theoretical proportion, and so, in most instances, the percentage of effective work appears higher with the strong caps. With J.B., as stated in a previous article (page 179), our supply of powder ran out. We had

BLACK AND BROWN GUNPOWDERS.

Powder, and Length of Barrel.	Ordinary Caps.				Strong Caps.			
	Muzzle Velocity.	Actual Recoil.	Excess over Theory.	Effective Work.	Muzzle Velocity.	Actual Recoil.	Excess over Theory.	Effective Work.
	Ft.sec.	Ft.lb.	Pr cent.	Per cent.	Ft.sec.	Ft.lb.	Pr cent.	Per cent.
No. 2 Bk.:								
30 in.	1122	32·2	111%	47½%	1136	33·1	106%	48½%
26 in.	1115	30·7	98	50½	1134	32·1	100	50
22 in.	1075	31·4	118	46	1085	31·6	115	46½
18 in.	965	29·1	150	40	967	29·3	151	40
14 in.	898	25·5	158	39½	896	26·4	163	38
10 in.	813	23·0	180	35½	816	23·9	187	35
Average	998	28·8	135%	43%	1006	29.4	137%	43%
No. 4 Bk.:								
30 in.	1114	31·5	104%	49%	1128	31·6	99%	50%
26 in.	1089	29·6	100	50	1086	30·4	106	48½
22 in.	1046	29·1	113	47	1051	29.0	110	47½
18 in.	963	28·8	149	40	964	28·8	149	40
14 in.	868	26·7	184	35	868	26·7	184	35
10 in.	793	23·5	199	33½	811	23·5	186	35
Average	979	28·2	141%	42%	985	28·3	139%	42½%
No. 6 Bk.:								
30 in.	1051	27·0	96%	51%	1009	26·3	96%	50½%
26 in.	935	25·0	129	43½	934	24·9	129	43½
22 in.	910	25·2	144	41	914	24·7	137	42
18 in.	876	23·9	150	40	875	24·3	154	39
14 in.	792	22·1	182	35½	794	22·1	180	35½
10 in.	710	18·4	192	34	718	19·2	199	33½
Average	879	23·6	149%	41%	874	23·6	150%	40½%
Brown:								
30 in.	1022	27·1	108%	48%	1021	27·4	111%	47½%
26 in.	1034	29·9	124	44½	1032	30·1	126	44
22 in.	929	25·8	139	43	936	25·8	136	42½
18 in.	811	22·3	172	37	819	22·4	168	37½
14 in.	747	20·3	191	34½	762	20·7	186	35
10 in.	684	16·8	188	34½	726	18·1	174	36½
Average	871	23·7	154%	40%	883	24·1	150%	40½

NITRO-COMPOUNDS.

Powder and Length of Barrel.	Ordinary Caps.				Strong Caps.			
	Muzzle Velocity.	Actual Recoil.	Excess over Theory.	Effective Work.	Muzzle Velocity.	Actual Recoil.	Excess over Theory.	Effective Work.
	Ft.sec.	Ft.lb.	Pr cent.	Per cent.	Ft.sec.	Ft.lb.	Pr cent.	Per cent.
Schultze:								
30 in.	1113	26·9	74%	57½%	1136	27·6	71%	58½%
26 in.	1075	24·9	72	58	1081	26·8	84	54½
22 in.	988	24·5	101	49½	1015	26·6	106	48½
18 in.	1007	25·7	103	49	1026	25·9	97	50½
14 in.	974	23·8	101	49½	1005	25·1	99	50
10 in.	826	19·4	127	44	861	20·6	122	45
Average	997	24·2	96%	51%	1021	25·4	96%	51%
E.C. Powder								
30 in.	1106	26·7	75%	57%	1135	27.3	70%	59%
26 in.	1033	23·0	73	58	1062	25·3	80	55½
22 in.	964	23·2	100	50	1016	24·2	88	53
18 in.	982	23·4	94	51½	1010	23·4	84	54½
14 in.	893	21·9	120	45½	926	22·4	109	48
10 in.	788	19·2	148	40½	844	19·6	120	45½
Average	961	22·9	102%	50½%	999	23·7	92%	52½%
S.S. Powder								
30 in.	1110	27·5	79%	56%	1150	28·9	75%	57%
26 in.	1016	24·9	93	51½	1071	27·1	89	53
22 in.	991	24·7	102	49½	1024	26·4	102	49½
18 in.	1016	26·4	105	49	1036	26·7	99	50
14 in.	924	23·9	124	45	966	25·2	116	46
10 in.	828	21·3	149	40	850	21·9	143	41
Average	981	24·8	109%	48½%	1016	26 0	104%	49½%
J.B. Powder								
30 in. (dry)	1061	22·2	58%	63½%	—	—	—	—
30in. (damp)	916	18·8	80	55½	1009	21·7	71%	58½%

taken some 80in. records with this powder with ordinary caps, before resolving to experiment with strong caps; but when we afterwards wished to try J.B. again with both kinds of caps, we found that what little we had of the powder had become damp, so that the records were much lower than they should have been, and, not being able to obtain a fresh supply, we can only present the foregoing records.

As already stated, in commencing upon the influence of strong caps on black powders, we have also had the various explosives tried by crusher-gauge apparatus. The force exhibited in this apparatus by all the black powders was lower with the strong caps than with ordinary ones; but especially was this the case with No. 6 grain, the pressure of which fell 8 per cent. at the first plug—an inch from the breech; the second plug was 2½in. and the third 6in. from the breech. In the last 2ft. of the barrel there was nothing to show how the pressure varied; but it may be surmised that there was a little increase somewhere, as there was a slight increase of muzzle velocity with No. 2 and No. 4 grain, but the recoil was practically identical with the fine-grain powder with both kinds of caps, although recoil diminished as well as velocity when the strong cap was used with the coarse-grain powder.

The percentages of increase or decrease under the respective heads are indicated by the plus (+) and minus (−) signs that precede the figures. Where the variation is too small to give an appreciable percentage, it is marked 0, although, strictly speaking, there may be a small fraction of increase or decrease. The pressures are stated in pounds per square inch.

BLACK AND BROWN POWDERS.

Powders and Caps.	Pressure on the three Crusher-gauge Plugs.			Muzzle Velocity.	Actual Recoil.
	1st.	2nd.	3rd.	Ft.sec.	Ft.lb.
No. 2 Black—Eley's caps ...	6520	6169	3901	1122	33·2
,, Kynoch's ,, ...	6245	6101	3863	1136	33·1
Percentage of variation	−4%	=1%	−1%	+1%	0%
No. 4 Black—Eley's caps ...	5608	5526	4746	1114	31·5
,, Kynoch's ,, ...	5427	5407	4643	1128	31·6
Percentage of variation.....	−3%	−2%	−2½%	+1%	0%
No. 6 Black—Eley's caps ...	4930	4746	3336	1051	27·0
,, Kynoch's ,, ...	4535	4643	3306	1009	26·3
Percentage of variation.....	−8%	−2%	−½%	−4%	−3%
Brown..... —Eley's caps ...	4039	4270	3412	1022	27·1
,, Kynoch's ,, ...	3811	4435	3031	1021	27·4
Percentage of variation.....	−5½%	+4%	−11%	0%	+1%

NITRO-COMPOUNDS.

Powders and Caps.	Pressures on the three Crusher-gauge Plugs.			Muzzle Velocity.	Actual Recoil.
	1st.	2nd.	3rd.	Ft.sec.	Ft.lb.
Schultze—Eley's caps ...	6433	5736	3713	1113	27·0
,, Kynoch's ,, ...	6662	6366	3760	1136	27·6
Percentage of variation ...	+3½%	+11%	+1½%	+2%	+2%
E.C. ..... Eley's caps ...	5475	4695	3455	1106	26·4
,, Kynoch's ,, ...	6399	5676	3522	1135	27·0
Percentage of variation ...	+17%	+21%	+2%	+2½%	+2%
S.S..... Eley's caps ...	5842	4710	3578	1110	27·2
,, Kynoch's ,, ...	5732	5695	3732	1150	28·6
Percentage of variation ...	−2%	+21%	+4%	+3½%	+5%
J.B. ..... Eley's caps ...	4356	3662	3103	916	18·6
,, Kynoch's ,, ...	4289	4435	3538	1009	21·4
Percentage of variation ...	−1½%	+21%	+14%	+10%	+15%

With the nitro-compounds, the strong caps always produced increased pressure at two of the plugs, if not at all three; but in two instances a small diminution at the first plug accompanied a larger increase at the second. It is rather curious that with three of the nitro powders the increase at the second plug was equal, viz., 21 per cent. We need hardly say that these increased pressures are not such as need create any fear of danger to the gun; as the pressures thus produced by strong caps on some powders were about the same as those exhibited by other powders with ordinary caps.

On examining the last two tables, it becomes apparent that the variation in recoil does not correspond with the variation in velocity. Whenever there is an increase or a diminution in the muzzle velocity of the shot, the recoil should, on theoretical grounds, rise or fall in the ratio of the square. Accordingly, as No. 2 and No. 4 black powder show 1% increase of velocity, they should show in the recoil an increase of 2% (omitting fractions); whereas their recoil record is practically unaltered. Again, when No. 6 shows 4% falling off in velocity, it ought to show over 8% reduction in recoil, instead of merely 3%.

With the nitro-compounds there is always an increase of recoil, but it does not come up to the due proportion. With Schultze it is 2% instead of 4%; with E.C., 2% instead of 5%; with S.S., 5% instead of 7%; and with J.B., 15% instead of 21%. This smaller proportion of recoil we attribute to the fact that, whether the force of the powder be increased or decreased by the alteration of the cap, the non-effective work remains nearly a constant quantity; whereas, if the velocity be increased by an addition to the powder-charge, the proportion of recoil would be increased by the greater amount of gaseous products.

An example of this effect will be seen in the following records of experiments with equal charges of shot, but different charges of powder. An ounce of shot was used in each instance, and the powder was No. 4 black.

Charge of Powder.	Muzzle Velocity.	Recoil registered.
3 drs.....	1125 ft.sec.	29·4ft.lb.
3¼drs., or 8% increase	1168 f.s., or 4% increase	32·6 ft.lb., or 11% increase.
3½drs., or 16% increase	1240 f.s., or 10% increase	35·2 ft.lb., or 21% increase.

The proportions, however, are by no means constant, but differ with the nature of the boring. The above was with a cylinder barrel. From the choked barrel of the same gun the results were as follows:

Charge of Powder.	Muzzle Velocity.	Recoil registered.
3 drs.....	1196 ft.sec.	29·1 ft.lb.
3¼drs., or 8% increase	1230 f.s., or 3% increase	31·6 ft.lb., or 9% increase.
3½drs., or 16% increase	1291 f.s., or 6% increase	35·5 ft.lb., or 22% increase.

An instance of the opposite effect is shown in the last line of the second table, where the record with damp J.B. powder is given. The dampness caused a great reduction in velocity, but left other matters practically unaltered. It did not, for instance, lessen the amount of powder products which had to force their way out of the muzzle. So the effective portion of the work was diminished, while the non-effective part continued much the same as before. Accordingly the *proportion* of recoil was relatively increased, although its total had undergone some amount of reduction.

When the shot-charge was added to, and the powder remained stationary, the effect was different. There was no additional body of powder-gases to rush out; but, on the other hand, the friction of the larger mass of pellets caused a stronger "brake action," and thus tended to check the backward movement of the gun. Hence, the recoil produced by additional shot was below the theoretical percentage of increase, whereas the recoil produced by additional powder was in excess of it. P.—T.

BORLAND'S CAP-TESTING APPARATUS.

(*Field*, Aug. 13, 1892; Vol. 80, p. 251.)

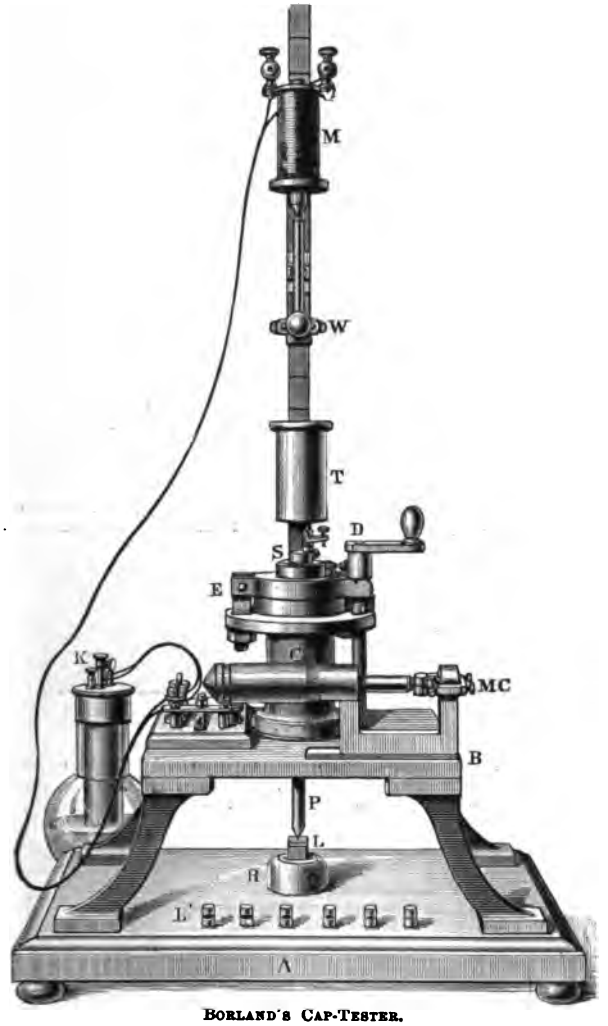
In giving this brief description of a new cap-testing apparatus which has been found capable of demonstrating and investigating the most important and practical points in connection with the behaviour of percussion caps, Mr Borland desires that the present paper be regarded rather as a contribution to existing knowledge of testing appliances than as a claim to any very great originality or superiority over methods which may be in vogue; but it is believed that in one particular, at least, a new and advantageous departure has been made, viz., in regarding percussion caps on their own merits as explosive charges, and in measuring the actual energy produced by their explosion, irrespective of their igniting or exploding action for powders.

The apparatus is capable of demonstrating the following points: (1.) Nature and strength of blow required to ignite with certainty percussion caps of any particular make. (2.) Influence of shape and

size of striker. (3.) Actual explosive force produced by the cap *per se*, irrespective of its igniting action for powders or explosives. (4.) Time elapsing between the delivery of blow to striker and development of a flash of any specified length. (5.) Igniting power at various distances or on various explosives.

In the accompanying figure, the apparatus is shown as ordinarily used for the carrying out of tests 1, 2, and 3; but the accessories required to carry out the other tests are very simple, and can be attached at a moment's notice.

The wooden base, A, provided with levelling screws, carries an iron table, B, in the centre of which a steel cylinder, C, with hinged cover, E, is fitted. The cylinder serves as a holder for the cartridge or cap



BORLAND'S CAP-TESTER.

under examination, and the hinged cover, E, is bored out in the centre for striker, S. Upon the right-hand side of the hinged cover, the screw nut, D, is provided for the purpose of clamping the cover down firmly, in order to confine the cartridge case or cap.

Upon the iron table and behind the cylinder, graduated into inches and fractions, a standard is erected; and this serves to carry the electro-magnet, M, upon a suitable clamp, which can be fixed at any point on the standard.

The weight, W, shown suspended from the magnet, is ordinarily of 2oz. in weight, and falls in free air to deliver its blow upon the striker, when the current from battery to electro-magnet is interrupted by means of the switch or firing key, K, shown upon the left hand side of the iron table.

The proper levelling of the instrument, to insure the blow being delivered upon the centre of the striker, is attained with the assistance of a plummet carried by a silken thread wound upon a small steel reel, which can be suspended from the electro-magnet. The levelling screws are worked until the point of the plummet coincides with the centre of the striker; and, the length of thread being adjustable upon the reel, it is possible to test the accuracy of levelling when the magnet is at any position upon the rod, and so deviations from truth of any part of the standard can always be neutralised.

The tube, T, carried upon the standard a short distance above the hinged cover, E, is open at both ends, and simply serves to catch the weight after is has delivered its blow upon the striker.

The cylinder, C, is bored through from end to end, and suitable bushes are provided for the purpose of holding cartridge cases of different gauges, or percussion caps not fitted into cartridge cases.

In carrying out the first test above mentioned, namely—the determination of minimum blow required—it is of course necessary to try as large a number of caps as possible in each series, as in every batch there appears to be a certain percentage of extra-sensitive caps, which explode with a smaller blow than suffices to give, say, twelve consecutive good explosions. It has been frequently observed that a difference of one inch more or less in the height from which the weight falls is sufficient to determine certainty or uncertainty of detonation.

The weight, and also shape, of striker point, largely influence the results, and the well-known recommendations of the cartridge manufacturers on both these particulars have been amply confirmed.

In point of sensitiveness, the percussion caps in "E.C." cases of recent issue are remarkably good, and repeated experiments have proved that a weight of 2oz. falling from 12in. in free air, and delivering its blow fairly on the centre of the striker, is sufficient to detonate with certainty and completeness the caps in the present season's issue of Bachmann, Eley, Joyce, and Kynoch ordinary E.C. cartridges.

Some caps lacking in sensitiveness, and known to give trouble in the gun, were found to require a 30in. fall of the 2oz. weight; and even then a certain percentage did not explode properly, but simply fizzed off—proving the possibility of hang-fire being caused by the cap requiring a more powerful blow than usual to detonate it properly.

In obtaining the above results the striker weighed 100gr., whereas gun-strikers appear to vary between 25gr. and 50gr. in weight; but the experimental striker has been purposely made heavy in order that the test may be as severe as possible, and also to take into account the possibility of gun-strikers not working with the same freedom as the experimental striker, by reason, for example, of a very small amount of corrosion, which would materially increase resistance and render the blow upon the cap less lively.

In order to judge whether a proper detonation is effected, three methods of observation may be employed. The sound of the explosion affords a very good criterion; or the flash may be received upon paper and the amount of charring and residue observed. In these cases the plunger, P, which appears underneath the iron table, is withdrawn, leaving a clear passage for the flash.

The best plan, however, is to measure the actual explosive force produced, and this is arrived at in the following manner:—A steel tube 6in. in length, accurately bored to take the plunger, P (and of same outside diameter as the inside of cartridge case), is inserted in the cylinder, C, and rests upon a screw sleeve in the bottom of the cylinder. An indiarubber disc or wad, with central aperture corresponding with the dome of the cap-chamber, is placed inside the cartridge, and, on the cartridge case being inserted in the cylinder, the end of the steel tube becomes bedded upon the indiarubber wad. When the hinged cover, E, is closed and clamped down, the tube is finally tightened against the indiarubber wad by means of the screw sleeve, and the entire force of the explosion of the cap can only be exerted upon the plunger.

As shown in the drawing, the plunger carries a knife or chisel at its lower end, and the force exerted is registered by the depth this chisel penetrates cylinders of compressed lead.

The cuts so produced are gauged in micrometer callipers (MC), specially adapted for the purpose, and the results are most accurately expressed by the actual measurements obtained. However, a satisfactory curve has been experimentally worked out, and, if desired, expressions in terms of energy can thereby be arrived at; but, as such expressions can only be approximations to the truth, the actual measurements are properly preferred.

A good cap for nitro-compounds should give a large hot flame, with a minimum of explosive or detonating power; and, whilst it is very far from the object of this article to enter into a controversy upon the relative merits of different caps, it is due to Messrs Eley to point out that their small caps of this season's issue show a very great advance, not only in the above particulars, but also in respect of sensitiveness.

Considerable care has to be exercised in carrying out the pressure test in respect of the proper lubrication of the plunger, the quality of the lead cylinders, the condition of the knife-edge, and the distance of the upper end of plunger from dome, that there may be no variation in the air space; but with the usual precautions observed in scientific work the results obtained are very concordant.

The following figures giving depths of cut in the leads may be interesting.

Good caps.

·060″
·072″
·067″
·071″
·066″

Caps unsatisfactory on account of occasional miss-fire and hang-fire. Three series taken on different days.

·042″	·040″	·019″
·058″	·045″	·052″
·053″	·060″	·037″
·019″	·047″	·037″
·047″	·018″	·046″

Caps unsatisfactory on account of occasional extra strength.

·103″
·070″
·073″
·120″
·101″

The description of the details involved in estimating time elapsing between delivery of blow to striker and development of a flash of any specified length cannot very well be undertaken without further illustrations, but the principle involved consists essentially in making the movement of the striker break one circuit of the Boulengé chronograph, the second circuit being interrupted by the ignition in the path of the flash of a small fragment of explosive which holds a contact up to its work. The explosive being ignited, the current is interrupted and registration effected in the usual manner.

The ignition test is preferably taken in conjunction with the time test, but the accessory apparatus would require special illustration.

We spent a day with Mr. Borland, experimenting with caps by various makers, and the results came out very similar to those above stated. We consider Mr. Borland deserves great credit for the design of his experimental apparatus.

It should be added that, in constructing this apparatus, Mr. W. D. Borland, F.C.S., of the E.C. Powder Company, received the assistance of his brother, Mr. C. R. Borland, in respect of some of the working details.

CAPS AND THE IGNITION OF POWDER.

(*Field*, May 1, 1897; Vol. 89, p. 657.)

A LECTURE on this subject, by Mr W. D. Borland, of the E.C. Gunpowder Company, was delivered at a meeting of the Gunmakers' Association in April, 1897, and the following is a summary of the paper read:—

The subject of the proper ignition of explosives in general, and nitro explosives in particular, in small-arm cartridges is one of the utmost importance to all who are in any way connected with the preparation and use of ammunition, and it is one which has engaged the attention of experimentalists for many years past, with the result that no little progress has been realised. The difficulties surrounding the investigation of this subject are by no means small, owing to the impossibility of placing, in the interior of small-arm cartridges suitable measuring or recording apparatus; and even the cutting of a small hole in a cartridge case for the purpose of crusher-gauge work is often sufficient to disturb the real conditions of practice. Hence it becomes necessary to employ an analytical and inductive method of research, and to trace individually the effect of various factors which are concerned in the ignition of powders in small-arm cartridges. The ideal means of ignition may be generally laid down as that whereby the most perfect ballistics are obtained with the lowest strain on the weapon, combined with regularity and freedom from undue sensitiveness to variations in mechanical conditions of the firing mechanism (such as strength of blow and shape of striker). This, like most other ideals, is difficult of attainment; but it is only just to the various manufacturers of cartridge cases to emphasise the marked progress that has been and is still being made, in face of difficulties of experimenting with a material like cap composition, of difficulties of a mechanical nature, and perhaps, most of all, of the very varied requirements made from time to time consequent upon new powders being placed on the market.

In determining the suitability of ignition for any particular explosive, the final court of appeal is, of course, actual practice in the field and elaborate and rigorous determinations of ballistics; but such appeal is naturally cumbersome, and, after all, only shows whether the ignition is or is not suitable, without indicating in what particular or particulars the success or failure has its origin.

So far as research has gone up to the present, the following are conditions upon which the behaviour of a cap depends, viz., (1) total energy of explosion; (2) size and shape of flame; (3) duration of flame, temperature of flame, or, perhaps, to speak more properly, heating effect of flame; and (4) sensitiveness of the cap to altered conditions of blow.

As regards the total energy of explosion, the lecturer, in 1891, devised an apparatus for the determination of energy, a description of the apparatus and results appearing in the *Field* (see page 221), and afterwards in other publications. As this matter was gone into fully at the time, it need not be here further referred to beyond pointing out that recent experiments conducted by the *Field*, with a modification of the lecturer's method, clearly show that the energy test initiated by Mr Borland is of no little value as a test of regularity; but beyond this Mr Borland's experience shows that the energy test, taken by itself, does not afford more than a mere approximation to the igniting power of a cap, and, by itself, is not capable of being employed for the comparison of the true igniting effect of caps of different makes and different compositions.

After an infinite amount of experimental work, Mr Borland has been able to devise a photographic method of recording the characteristic qualities of the flames produced by various caps in respect, not only of shape, size, and intensity, but also of duration, and it is now possible to indicate and record results in a graphic manner hitherto unattainable. When it is remembered that the total amount of flame-producing composition in a percussion cap may not exceed 0·6gr., and the duration of the flame is to be measured, not by tenths, but by ten-thousandths of a second, it will be at once seen that any photographic method must involve the employment of sensitive plates of greatest possible speed, and lenses of greatest possible aperture, and further, if the results are to be trustworthy, that the speed of the plates must be regular, and the methods of development of image uniform. On all these points the lecturer has been able to overcome the initial difficulties, and some results selected out of some 1200 flame photographs recently taken are reproduced, one-fifth of the actual size.

Fig. 1 represents the characteristic flame picture of an issue of one of the strongest quick-burning large caps in use some five years ago.

Fig. 1.

Fig. 2 represents a small cap of recent issue which produces about the same energy as No. 1, but which, as compared with No. 1, shows a marked improvement in volume of flame.

Fig. 2.

Fig. 2A is from the same batch as No. 2, but in this case the blow on the striker, whilst sufficient to avoid misfires, was insufficient to produce perfect detonation in more than two out of the five instances.

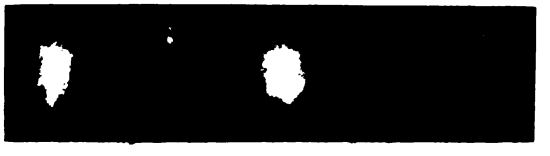


Fig. 2A.

Fig. 3 represents a recent issue of large nitro caps, and is certainly irreproachable.

Fig. 3.

Fig. 4 is the same as No. 3, but the striker used for this series was of slightly smaller diameter than recommended by the makers; and the end more coned than deemed desirable by them. The moral is obvious.

Fig. 4.

Fig. 5 is the same cap as No. 3 and same proper striker, but the blow was not a lively one, being delivered by a 24oz. weight, falling respectively 2in., 2¼in., 2½in., 2¾in., and 3in. It will be observed that the depreciation proceeds as the blow increases, and it is thus evident that a strong nipping sort of blow is to be avoided as much as a weak one.

3in. 2¾in. 2½in. 2¼in. 2in.

Fig. 5.

Fig. 6 is a continuation of No. 5, and shows a series exploded with a 24oz. weight falling 3in. The effect has been to break up the composition and to expel it in burning fragments from the flash-hole.

Fig. 6.

Fig. 7 is a most excellent series representing a batch of small caps made some seven years ago to a particular specification. They give the largest amount of energy of any here referred to, but in spite of this they ignite the powder charge in such a way that, whilst the maximum velocity is attained, the pressures in the chamber are remarkably low. This Mr Borland has found to be the case not only with service charges but also with proof charges; and this paradoxical result he has found to be due to the comparatively slow rate at which this particular cap evolves its energy. Further reference is made to this matter below.

Fig. 7.

Fig. 8 represents a cap largely used for a concentrated powder. The flame is not large, but, as the energy is high and duration small, it is evidently of the type in which a small volume of gas is produced at high temperature and pressure.

Fig. 8.

Fig. 9 is a different type of cap, also used for concentrated powder. In this make the cap chamber is large enough to contain about 2grs. of powder, consequently the cap flash is reinforced by the portion of powder charge intimately in contact with it.

Fig. 9.

In all the above the cartridge case was cut off near the base, so that the dome and flash hole projected, and the whole picture of the flame was accessible to the lens.

Fig. 10 gives an idea of the length of flame produced by various caps fired in the full length case.

Fig. 10.

Concerning Fig. 7, Mr Borland for some time was unable to discover why this cap, though of very high energy, and producing such large flame, did not give rise to such high chamber pressures with any powders as did other caps of lower energy and smaller flame; and it occurred to him that possibly this might be due to a progressive action, and that this particular cap was comparatively slow burning, and that its excellent igniting qualities were due to its maintaining its action even whilst the shot charge was passing up the barrel.

To prove this point, Mr Borland devised an apparatus consisting of a small electro-motor run by accumulator cells at about 3000 revolutions per minute, the exact speed being determined by the well-known tuning fork method. Upon the shaft, and at right angles to it, a disc was attached, serving to carry a sensitive plate. In front of the plate, but not attached to it, was a fixed screen in which, coinciding with the centre of revolution of the plate, a fine parallel slit was cut. It will at once be understood that if a cap is fired behind the screen, the plate not revolving, the illumination will cause a parallel band of light to pass through the screen slit, and will impress this image on the sensitive plate. If, on the other hand, the plate is revolving, then the parallel band broadens out into a wedge-shaped image, the angle of which is dependent upon the ratio which the duration of the flame bears to the velocity of revolution of the plate.

Instead of a plate, a band of sensitive paper upon a drum may be used, in which case the thin parallel band is simply broadened out; but Mr Borland prefers the first method, as, by using glass plates, measurement of the results may be facilitated by projecting the image by means of an optical lantern on to a screen divided off protractor-wise. Working in this way Mr Borland has found that the durations of cap flames vary as much as 400 to 500 per cent., the actual durations being from ·0002 to ·001sec., and he was able to prove that cap No. 7, above referred to, gave the longest duration of any under experiment.

So far as Mr Borland is aware, this question of duration of flame has never been definitely recognised before, but it appears to be of no little importance.

BIRMINGHAM PROOF HOUSE REPORT, 1895.

(*Field*, May 9, 1896; Vol. 87, p. 700.)

THE Guardians' report has recently been issued, and in the main may be regarded as satisfactory, especially as the chart shows that during the past year there has been a slight improvement in the Birmingham gun trade. This happy state of things is necessarily reflected in the Proof House statistics, with the result that during 1895 the sum received for barrels proved amounted to £3866. 10s. 2d. against £3284. 1s. 11d. in 1894. The rifle shooting ground would, however, appear to have been less used than in the year 1894. Then the income from this source of revenue was upwards of £50, whereas in 1895 it was no more than £36. 8s. 1d., that sum representing 590 occasions of the ground being used, whereas in 1894 it was occupied 844 times. This is a somewhat surprising item of information, though there may be local reasons to account for the falling off. It is also a matter for congratulation that no accident has happened during the past year either at the Proof House or the shooting range, while the law-abiding nature of the trade is shown by the fact that no offences against the statute have come under notice.

That proof houses are not superfluous institutions is made clear by the fact that out of 11,610 single sporting guns received no fewer than 518 cracked under the strain of provisional proof; 68 were broken, 222 were bulged, and in six cases huts were blown out. There were 108 examples of unsound breeching, while the nipples were blown from 66 guns. No fewer than 47,684 double barrels were

Statement of barrels received for proof, marked as proved, or found faulty, during the fifty-two weeks ending Dec. 31, 1895.

DEFINITIVE PROOF.

TWISTED GUN BARRELS.	Received.	Marked.	Cracked.	Broken.	Bulged.	Nipples Blown out.	Unsound Breeches.
Single Birding Barrels, One Proof only	—	—	—	—	—	—	—
Double Birding Barrels, One Proof only	15,453	15,130	143	78	49	47	6
Single Birding Barrels, Second Proof	—	—	—	—	—	—	—
Double Birding Barrels, Second Proof	1,306	1,285	1	6	11	2	1
Military Barrels, One Proof only	—	—	—	—	—	—	—
Military Barrels, Second Proof	—	—	—	—	—	—	—
Barrels, Large Bore: One Proof only	—	—	—	—	—	—	—
Barrels, Large Bore: Second Proof	—	—	—	—	—	—	—
	16,759	16,415	144	84	60	49	7

DEFINITIVE PROOF—continued.

PLAIN IRON AND STEEL GUN BARRELS.	Received.	Marked.	Cracked.	Broken.	Bu'ged.	Nipples Blown out.	Unsound Breeches.
Double Birding Barrels, One Proof only	2839	2779	36	43	13	7	1
Single Birding Barrels, Second Proof	—	—	—	—	—	—	—
Double Birding Barrels, Second Proof	888	867	4	8	5	2	2
	3777	3646	40	51	18	9	3

BREECH-LOADING ARMS.	Received.	Marked.	Cracked.	Broken.	Bulged.	Broken Actions.	Actions off the Face.	Defective Actions.	Foreign Arms received for Proof without notice of importation. Received.	Marked.	Defective Actions.	Cracked.	Broken.
Birding Barrels: One Proof only	615	612	—	—	—	1	2	—	—	—	—	—	—
Do. Foreign	1,313	1,312	—	1	—	—	—	—	59	59	—	—	—
Second Proof	30,586	30,060	89	79	237	4	112	6	—	—	—	—	—
Do. Foreign	664	664	—	—	—	—	—	—	4,254	4,254	—	—	—
Large Bore	176	175	—	1	—	—	—	—	—	—	—	—	—
Choke Bore	22,803	22,720	12	16	42	—	13	—	—	—	—	—	—
Large Bore } Choke Bore }	170	169	—	—	1	—	—	—	—	—	—	—	—
Military Barrels: One Proof only	194	194	—	—	—	—	—	—	—	—	—	—	—
Do. Foreign	—	—	—	—	—	—	—	—	138	138	—	—	—
Second Proof	14,737	14,618	2	18	1	—	—	98	—	—	—	—	—
Do. Foreign	—	—	—	—	—	—	—	—	9,119	9,004	102	9	4
	71,258	70,524	102	115	281	5	127	104	13,570	16,455	102	9	4

PISTOLS.	Received.	Marked.	Broken.	Blown Jnts.	Foreign Pistols received for Proof without notice of importation. Received	Marked.	Broken.	Blown Joints.
Chambers in Revolving Pistols (load in the cartridge)	28,853	28,853	—	—	—	—	—	—
" " " Foreign	5,522	5,516	6	—	6183	6179	3	1
Chambers and Barrels in Revolving Pistols with Nipples	112	112	—	—	—	—	—	—
" " " Foreign	142	142	—	—	101	101	—	—
	34,629	34,623	6	—	6284	6280	3	1
Total number of Barrels received	146,277	—	—	—	—	—	—	—

received, and of these 1293 cracked, 300 were broken, 2308 bulged, and 55 had the huts blown out. In the plain iron and steel division 8497 barrels were marked out of the total number received of 9340; 574 were broken, 21 had faulty vent holes, 26 had the huts blown out; there were 54 cases of split breeches, 78 instances of unsound breeching, 42 cases of blown nipples, 11 bulges, and 37 faulty insides; these being in single barrels alone, and, of course, for provisional proof only. The chief thing to be noticed in connection with the military barrels (double proof) is that 332 had the huts blown out, and 195 bulged, out of 28,812—the number received. The pistols came out pretty well, as no more than 46 out of the 1048 submitted to provisional proof broke. The result of the definitive proof is appended.

Provisional proofs, at tariffs varying from 1d. to 3s. 6d., produced altogether £1688. 12s. 6d., showing an increase of something like £88 on the total of 1894. The definitive proofs, which in the previous year brought in £1683. 0s. 4d., have now risen to £2177. 17s. 8d., the whole year's income being £4272. 8s. 7d.

THE PROOF OF GUNS WITH FINE-GRAIN POWDER.

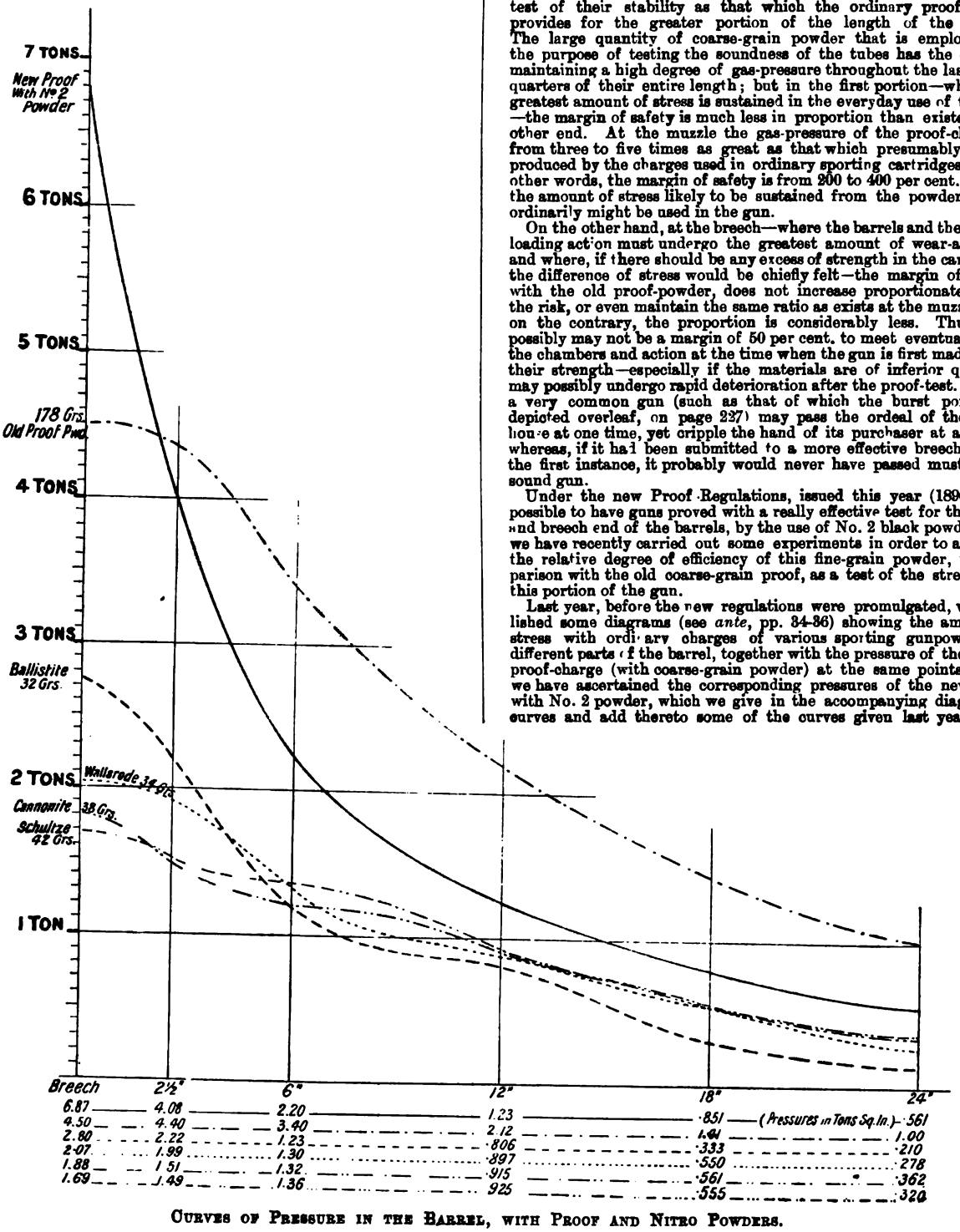
(*Field*, Nov. 21, 1896; Vol. 88, p. 812.)

BREECHES and actions of guns have long needed as efficient a test of their stability as that which the ordinary proof-powder provides for the greater portion of the length of the barrels. The large quantity of coarse-grain powder that is employed for the purpose of testing the soundness of the tubes has the effect of maintaining a high degree of gas-pressure throughout the last three-quarters of their entire length; but in the first portion—where the greatest amount of stress is sustained in the everyday use of the gun—the margin of safety is much less in proportion than exists at the other end. At the muzzle the gas-pressure of the proof-charge is from three to five times as great as that which presumably may be produced by the charges used in ordinary sporting cartridges—or, in other words, the margin of safety is from 200 to 400 per cent. beyond the amount of stress likely to be sustained from the powders which ordinarily might be used in the gun.

On the other hand, at the breech—where the barrels and the breech-loading action must undergo the greatest amount of wear-and-tear, and where, if there should be any excess of strength in the cartridges, the difference of stress would be chiefly felt—the margin of safety, with the old proof-powder, does not increase proportionately with the risk, or even maintain the same ratio as exists at the muzzle, but, on the contrary, the proportion is considerably less. Thus there possibly may not be a margin of 50 per cent. to meet eventualities in the chambers and action at the time when the gun is first made, while their strength—especially if the materials are of inferior quality—may possibly undergo rapid deterioration after the proof-test. Hence a very common gun (such as that of which the burst portion is depicted overleaf, on page 227) may pass the ordeal of the proof-house at one time, yet cripple the hand of its purchaser at another; whereas, if it had been submitted to a more effective breech-test in the first instance, it probably would never have passed muster as a sound gun.

Under the new Proof Regulations, issued this year (1896), it is possible to have guns proved with a really effective test for the action and breech end of the barrels, by the use of No. 2 black powder; and we have recently carried out some experiments in order to ascertain the relative degree of efficiency of this fine-grain powder, in comparison with the old coarse-grain proof, as a test of the strength of this portion of the gun.

Last year, before the new regulations were promulgated, we published some diagrams (see *ante*, pp. 34-36) showing the amount of stress with ordinary charges of various sporting gunpowders at different parts of the barrel, together with the pressure of the official proof-charge (with coarse-grain powder) at the same points. Now we have ascertained the corresponding pressures of the new proof with No. 2 powder, which we give in the accompanying diagram of curves and add thereto some of the curves given last year. We



CURVES OF PRESSURE IN THE BARREL, WITH PROOF AND NITRO POWDERS.

do not give particulars of the whole of the nitro powders, but only of those which may be considered typical ones, as others among them would show curves so nearly representing those printed, that their insertion in the diagram would only tend to produce confusion.

We may mention that the charges of nitro powders used in the former experiments were the same as sufficed to give equal velocity to that produced by the use of 3drs. of No. 4 black powder; and we may also add that the charges of some of the concentrated nitro powders were then rather heavier than are now used with more recent samples of the same powders; but, though the strength of the samples has somewhat varied as compared with weight, the general characteristics of the powders remain the same. Here it will be observed that whereas some of them give rather high pressures in the chamber and diminish rapidly towards the muzzle, others have a lower pressure at first, but fall off more gradually, and thus show higher pressures towards the end of the barrel.

Similar effects are produced by the two black powders now used for proof purposes, as will be seen by the two uppermost curves in the diagram. The fine-grain powder commences with a pressure of about 6½ tons per square inch at the breech, and dwindles away to little more than half a ton at 6in. from the muzzle; whereas the old coarse-grain proof powder begins with 4½ tons, and ends with 1 ton. The use of these two powders should give most efficient evidence of the soundness of a gun—the fine powder testing the strength of the breech and action, while the coarse tests the barrel throughout, by the sustained pressure from the slowly-developed body of gases; and the margin of safety is now in nearly the same proportion at both ends of the barrel.

The figures stating the pressures, under the diagram of curves, represent the averages of half a dozen rounds with each of the powders at six points in the barrel. Full details of these were stated in a previous article (page 34). The charge of the ordinary proof-powder was 6½ drams, with 1⅛oz. of shot. Here we give similar particulars with the new proof test, viz., 4½drs. of No. 2 T.S. powder with 1⅛oz. of No. 6 shot:

PRESSURES IN TONS PER SQUARE INCH.

Plugs—	1st.	2nd.	3rd.	4th.	5th.	6th.
	6·57	4·08	2·08	1·15	·819	·575
	7·39	3·90	2·16	1·22	·781	·504
	7·08	4·12	2·25	1·29	·883	·504
	6·44	3·98	2·12	1·22	·819	·575
	6·44	4·24	2·49	1·22	·955	·636
	7·28	4·16	2·12	1·29	·847	·575
Averages ...	6·87	4·08	2·20	1·23	·851	·561

Unfortunately, this new proof is only permissory, not compulsory; and, consequently, it will not protect the purchasers of common guns, as the makers of such trash as the one depicted in the next page are not likely to pay an extra fee for the purpose of obtaining a more severe test, which would probably render the trash unsaleable. The remedy, however, lies in the hands of purchasers: they can refuse to buy any gun which does not bear a proof-mark showing that it has passed this new supplementary test.

We do not wish it to be inferred, however, that no gun can be trustworthy unless it bears this extra proof-mark. On the contrary, we would say that there are many trustworthy gunmakers whose wares would be equally as reliable if they bore no proof-mark whatever. Seeing that the main purpose of the proof of guns is not merely to bring fees into the coffers of the proof-houses—but to protect the lives and limbs of such of Her Majesty's subjects as make use of fire-arms; and inasmuch as the Legislature has thought fit to make some proof compulsory—it seems to us that the compulsion, if it be applied at all, should be enforced where it is most requisite. Otherwise the makers of the commonest guns are enabled to pass them on to purchasers with the same stamp of respectability (if such it can be called) as is compulsorily placed upon arms of the very highest quality. There is nothing whatever to indicate that the inferior guns ought not to be used with powders of great strength; but the most powerful of explosives are often used in the weakest of guns, whereas the proof which is compulsory applies only to a powder which is not so strong as those that are commonly used for sporting purposes.

The respectable gunmakers, however, are not entirely without a remedy, as they are enabled, at the cost of a shilling or two, to have a special stamp of high quality placed upon their productions. This they should have done for their own protection; and in a short time it would become generally understood among sportsmen that a gun without this *imprimatur*, if not old, is, in all probability, one of low grade. P.—T.

THE STRENGTH OF GUN BARRELS.

(*Field*, May 23, 1896; Vol. 87, p. 775.)

GUNMAKING is an ultra-conservative trade or profession, many of the methods employed by our forefathers being in full operation at the present day. To no part of the gun does this remark apply with so much force as to the barrel. Indeed, of this most important portion of the gun it may be truly said that its proportions are arrived at in a haphazard sort of way, the only rule employed being the "rule of thumb."

When a gunbarrel is required to withstand any unusual strain, the strength is proportioned according to the dictates of the maker's past experience. If the barrel passes the proof satisfactorily, it is delivered to the customer; but often in his hands the defect of weakness is developed after a few shots. Whenever a barrel shows decided signs of weakness, another is made a little stronger; and so on, until, after a great deal of time and money has been expended, the necessary dimensions are at last arrived at.

I here venture to point out the proper method to pursue in all such cases. First ascertain, by means of the crusher gauge, the pressure exerted by the charge intended to be used in the gun; then calculate what the thickness of the walls of the barrel must be to safely withstand such pressure; it being of course distinctly understood that the walls of the barrel are not to be weakened for any purpose whatever, such as dove-tails for the lump, or holes for extractors. In making this calculation, the most important point to be considered is the tensile strength of the metal used for the manufacture of gunbarrels. This may be safely taken as about 80,000lb. per square inch of section. But it is not safe to subject the metal to a greater stress than one-quarter of this amount; therefore we will take 20,000lb. per square inch of section as the highest working strain allowable.

The accompanying woodcut shows the breech end of a gunbarrel which, for the purpose of making my meaning clear, I will suppose to be 1 inch in length, 1 inch diameter of bore, and the walls of the barrel half an inch in thickness. Let us suppose that this barrel has burst along the dotted lines shown, and that we wish to ascertain the amount of pressure exerted by the powder gases which caused the fracture.

The sectional area of the metal broken is made up of the two walls of the barrel, which, taken together, are equal to 1 square inch; therefore the bore being 1 inch in diameter, the pressure exerted must have been equal to 80,000lb. per square inch. And if we wish to ascertain what the safe working pressure for such a barrel would be, all we have to do is to divide 80,000lb. (which represents the ultimate tensile strength of the metal) by 4, which gives 20,000lb., or about 8¾ tons per square inch, as the safe working pressure.

This method of calculation may now be tested by applying it to the barrel belonging to a 12-bore shot gun. There is not the slightest doubt that, owing to the great experience gunmakers have had with this kind of weapon, the proper thickness of the breech has long ago been arrived at by the rule-of-thumb method previously mentioned. In such a gun, with the service charge, a gas pressure of 3 tons, or 6720lb. per square inch, may be taken as being not far wide of the mark, the diameter of the chamber being about ·8 of an inch. Thus 6720lb., multiplied by ·8 and divided by 20,000lb. (which is the strain that 1 square inch of metal can safely bear) gives ·27 of a square inch as the sectional area of the walls of the barrel for every inch in length. This is exactly the thickness of the breech of a favourite 12-bore gun which I have now before me.

Having shown that this method of calculation is perfectly applicable to a 12-bore gun, it will now be shown what the thickness of the walls of a ·303 rifle barrel should be to take the Government Cordite cartridge, which gives a gas pressure, at 1 inch from the breech, of about 15 tons, or 33,600lb. per square inch. The diameter of the chamber is about ·425in.; therefore 33,600lb. multiplied by ·425 and divided by 20,000lb. gives ·714in. as the thickness of the walls of the

barrel; and, consequently, one half of this amount, viz., ·857in., is the thickness of metal which should surround the chamber.

This calculation is made for Cordite, which gives lower pressures than any other nitro powder suitable for this weapon. Some other nitro powders give very much higher pressures; and, therefore, rifles made to use such powders should be proportionally stronger.

However, sufficient has been shown to demonstrate that had simple calculations, such as here set forth, been made upon the introduction of the ·303 double rifle, hundreds of pounds and much valuable time would have been saved to gunmakers. H. F. PHILLIPS.

SHOOTING OF GUN AFTER FIRING 30,000 ROUNDS.

(*Field*, June 9, 1894; Vol. 83, p. 814.)

SIR,—I think probably the inclosed letter may prove of interest to your readers, showing, as it does, how good steel barrels will retain their shooting.

In this case, you will note, 30,000 rounds have been out of the barrel which gave the excellent results recorded. You will observe no "Field" wads were used in the loading with E.C. No. 2, and that thin card wads were used over the shot.

Braintree, Essex, June 6, 1894. G. THORPE BARTRAM.

Mr. G. Thorpe Bartram, Braintree.

Dear Sir,—You will doubtless remember building a gun for me, some seven years ago, with Whitworth steel barrels. I think you sent a contribution to the *Field*, giving the results obtained. The following patterns, obtained this afternoon from the left barrel, will perhaps be of interest to you: 42grs. E.C. No. 2, $\frac{1}{16}$in. card, $\frac{1}{8}$in. felt, $\frac{1}{32}$in. card, and $\frac{1}{32}$in. card over shot; 1$\frac{1}{8}$oz. No. 6 (270 to the ounce).

Ten Rounds, 30-inch circle, at 40 yards.										Average
253	247	262	258	261	256	273	262	256	270	= 260

As the gun has been in hard wear for the past seven years, and has had som thing like 30,000 shots fired from the barrel which gave the above, it occurred to me that probably it might interest you to have the figures, especially as they are representative of my daily test results.—Yours faithfully, W. D. BORLAND.

"E.C." Powder Company Limited; works, Green Street Green, near Dartford, Kent, June 5, 1894.

[The particulars given by Mr. Thorpe Bartram, nearly eight years ago, were published in the *Field* of July 3, 1886. The gun was tried on June 11, 1886, with 42grs. E.C. and 1$\frac{1}{8}$oz. of shot (270 to oz.) with four kinds of cases, and the following wads—first, "Field" wad, second $\frac{1}{8}$in. felt, third thin white card, and another thin card over the shot. The patterns given by the respective cases were as follows:

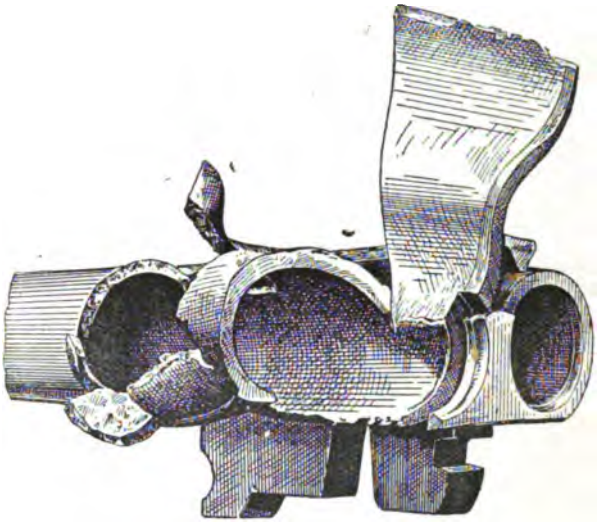
Ten Rounds each, 30in. circle, at 40 yards.										Averages.
Kynoch's	231	236	231	223	247	236	236	239	245	224 = 234
Joyce's	236	235	243	247	267	257	258	232	248	246 = 246
Bailey's	233	235	236	227	232	235	215	217	229	233 = 229
Eley's	259	228	238	225	225	229	230	220	238	236 = 232

The number of the gun was 1197, it weighed 7lb. 2oz., and the barrels were of Whitworth steel. Only the left barrel, full choke, was used in these trials; and from Mr. Borland's letter it appears that, after firing 30,000 rounds, it shoots rather closer than when it was first made; but the powder, we believe, is not exactly the same, the original E.C., as used eight years ago, having been supplanted by the E.C. No. 2, now in use; and there is also a difference in the wads used.—ED.]

A BURST GUN.

(*Field*, Nov. 7, 1896; Vol. 88, p. 731.)

WE have received for examination a burst gun (of which we give a photographic representation on a reduced scale), together with a number of cartridges which were being used at the time when the accident took place. We have tested the cartridges sent, some of which were loaded with black powder, and others with one of the new concentrated powders. No fault could be found with the cartridges—the pressures by crusher-gauge in no case exceeding 2$\frac{1}{2}$ tons per square inch; and the defect must be attributed solely to the defective condition of the barrel. It was a gun of the commonest kind, and probably when new was sold for about 50s. The barrels are of twisted iron, and where the burst took place it was imperfectly welded; and that will account for the metal being blown out in two places, with an intervening strap-like piece left intact between them. But the disaster was really caused by the flats of the barrels being filed away to such an extent that it was only a question of time for them to burst—which they eventually did, blowing two pieces from below upwards, and at the same time, we regret to add, carrying away the thumb of the shooter. The gun bore the fictitious name of "R. Adams, London," a firm no longer in existence, but which formerly had a reputation for very sound workmanship—of which reputation the unscrupulous maker of this gun probably wished to take advantage.



CHEAP GUN BURST IN CHAMBER.

We have frequently warned our readers against running the risk of purchasing very cheap guns. Too often, as in this case, such guns are fraudulent productions, with forged names. A few pounds may be saved by the purchaser, in the first instance; but what may be the ultimate cost? How many pounds would the unfortunate purchaser of this gun give if he could but restore his hand to its former unmutilated condition?

FRICTION OF SHOT CHARGES.

(*Field*, Sept. 17, 1892; Vol. 80, p. 444.)

SIR,—In your most interesting article on sizes of shot one rather important point is not touched on. Is it not a fact that the friction of large shot in the barrel is less than that of small shot? So that, with the same charge of powder, as great velocity and as little recoil would be obtained from 1$\frac{1}{4}$oz. No. 4 shot as from 1$\frac{1}{8}$oz. No. 7.

Consequently, as the real limits to the charge are recoil and strain, the energy in foot-pounds is on the side of the larger shot even more than is shown in your tables.

A man using No. 4 shot will use profitably 1$\frac{1}{4}$oz., while the man using No. 7 can only keep within the same recoil and strain, and maintain the same (even muzzle) velocity, by confining himself to 1$\frac{1}{8}$oz., or less. C. S.

[It is doubtless quite true that the friction of large shot in the barrel is less than that of small shot; but, from the results of some experiments published in the *Field* of Oct. 4, 1890, when charges of No. 2, No. 6, and No. 8 shot were fired under exactly the same conditions, the amount of recoil recorded was very nearly the same for each—No. 2 being 34·4 ft.lb., No. 6, 34·2 ft.lb., and No. 8, 34·4 ft.lb. The chief effect of the friction was shown by the difference in muzzle velocity—that of No. 2 being 1120 f.s., No. 6, 1080 f.s., and No. 8, 1060 f.s. Hence it may be said that, although the actual amount of recoil was virtually equal with the three sizes, it was relatively lowest with the largest shot—seeing that, according to commonly accepted rules, the recoil should be greatest with the highest velocity, and should increase as the square of the velocity. What may be the exact effect of increasing the charge of shot from 1$\frac{1}{8}$oz. to 1$\frac{1}{4}$oz., and leaving the powder unchanged, we cannot say without experiment; but we can hardly expect an addition of more than 10 per cent. to be made to the shot charge without adding to the recoil, unless the muzzle velocity is considerably reduced.—ED.]

THE CAUSE OF A BULGED BARREL.

(*Field*, Nov. 7, 1896; Vol. 88, p. 731.)

A VERY curious accident recently happened to the barrels of a 12-bore breech-loading double rifle, an account of which, we think, will be of interest to our readers.

The makers of the rifle ordered a quantity of cartridges from a firm of ammunition manufacturers, to be loaded with 12-bore spherical ball; but the bullets placed in the 12 bore cases, instead of being of the proper size, were of 16 gauge; and when the cartridges were fired, the results were as follows: The recoil caused by the discharge of the right barrel dislodged the bullet from the cartridge in the left barrel, owing to its looseness, and the ball rolled some distance up the bore, without the fact being perceived. When the left cartridge was fired, the pressure of the imprisoned air, between the powder-wad and the bullet, became so great, before the inertia of the bullet could be overcome, as to bulge the barrel about three or four inches from the muzzle.

We, as arbitrators between the manufacturers of the cartridges and the makers of the rifle, were requested to experiment on the undamaged right-hand barrel. We first fired a number of rounds with the bullet in its proper position in the cartridge, and no injury to the barrel resulted; but on placing a loose bullet in various positions near the muzzle, we succeeded, in every instance, in producing facsimile bulges to those existing in the left barrel, thus proving that the damage to the rifle was caused by the carelessness of the loaders of the cartridges, in substituting 16-bore in place of 12-bore bullets.

(*Field*, Nov. 14, 1896; Vol. 88, p. 773.)

SIR,—We venture to differ from your explanation of the accident described in your last issue. It is not easy to conceive how the air compressed between a rapidly-moving bullet and one that had slipped forward to near the muzzle (the latter being presumably far from air-tight) should fail to expel the forward bullet before the air had reached sufficient tension to bulge a rifle barrel. A bulge frequently takes place when a rapidly-moving bullet is suddenly checked by an inelastic obstruction, and will be found to lie close to, but behind it. It is apparently caused by the suddenly-increased tension of the powder gases, due to the arrest of their rapid movement and consequent momentary accumulation at that place. JOHN RIGBY AND CO.

72, St. James's street, S.W., Nov. 9, 1896.

[If Messrs Rigby will again look at the remarks which we published last week on this subject, they will find no allusion to a rapidly-moving bullet. There was only one bullet in the barrel when the bulge took place, and that one was near the muzzle.—ED.]

(*Field*, Nov. 21, 1896; Vol. 88, p. 813.)

SIR,—We have again looked at your remarks of Nov. 7. You say that you placed "a loose bullet" in various positions, but do not say you removed that in the cartridge. This is, however, immaterial to our argument, which is that the bulge is not in such a case caused by the compressed air between the moving body, whether wad or bullet, but by the powder gas in rear of the moving body when the latter is suddenly checked. JOHN RIGBY AND CO.

72, St James's-street, S.W., Nov. 17, 1896.

[If Messrs. Rigby would thoroughly investigate this subject for themselves, we think they would eventually arrive at the same conclusion as we have done. This is not the first time that causes of bulged and burst barrels have been discussed in the *Field*; and others have tried experiments as well as ourselves. About ten years ago Mr. Greener stated the results of some experiments which he had carried out; and these went to show that the effect produced by an obstructing charge of shot depended upon the distance of the obstruction from the breech, and the quantity of powder contained in the next cartridge that was fired. With a small charge of powder (1½drs.) and the blockage near the chamber, the obstructing shot and wads were pushed through the barrel without doing any injury to the gun; but when the second cartridge fired contained the full 3drs. of powder, and the obstruction was 12in. from the breech, the barrel burst at 14in. from the breech. The inference we draw from these facts is, that with a small air space between the two charges, and a low initial velocity in the second charge, the confined air is so slowly condensed that the inertia of the obstructing mass is gradually overcome, and the obstruction is removed without any intense pressure being set up; but that when there is a longer column of air in the barrel, and the charge of powder is large, the inertia of the obstructing mass cannot be overcome quickly enough, and the compressed air acquires enormous power, which ultimately either bursts the barrel or bulges it. Some other experiments, carried out by Mr. F. Beesley and Mr. Lincoln Jeffries, also go to support these conclusions. Subsequently (not then having any crusher-gauge of our own) we requested Mr. R. W. S. Griffith to carry out some experiments in his apparatus, with the view of ascertaining, if possible, what amount of pressure was developed by the first charge of shot and wads being left stationary in the barrel, and thus obstructing the passage of the second charge. One of the results of these experiments will be seen by the following illustration, which shows the effect produced on a solid steel barrel near the

Bulged 12-bore steel barrel, more than a quarter of an inch in thickness.

muzzle. A 1⅛oz. charge of No. 6 shot had been placed between wads about 2ft. from the breech, and, on a similar charge being fired with 3drs. of powder, a bulge of about an inch and a half in length was produced; and Mr. Griffith said (*Field*, Dec. 25, 1886): "The obstruction lay at 6in from the muzzle; the bulge commences at 5in., and has a centre at 4¼in. So the obstruction began to move, by pressure of compressed air, when the charge started, and was caught up by the advancing charge at about 4in. from the muzzle. The intervening air being so compressed, the walls of the barrel gave way. It is a singularly striking instance of the value of the contained air in the barrel." (The particulars of these experiments are given more fully *ante*, pp. 93-94.)

In this instance it will be observed that the obstructing charge was at 2ft from the breech, or double the distance of that in Mr. Greener's gun when it burst; but the bulged crusher-gauge barrel was probably three or four times the thickness of the ordinary gun barrel which was burst by a similar charge of powder. The rifle barrel that was damaged, as stated a fortnight ago, had the bulge about three or four inches from the muzzle; and the charge of powder that produced the bulge was 6 drams, or double as much as that used by Mr. Greener and Mr. Griffith. As there was no bullet to protect the powder wad would doubtless travel up the barrel more quickly than if there had been a bullet to drive through the rifling, and consequently there would be less time wherein to overcome the inertia of the obstruction. As to our own investigations, we may say that, as the result of experiments carried out some time ago, we are decidedly of opinion that Messrs. Rigby's theory with regard to bulges being caused by suddenly checking the motion of the particles of powder gas, is erroneous; and we hope, next week, to be able to publish the results of other experiments, which will settle the matter beyond doubt.—ED.]

BULGING AND BURSTING OF BARRELS THROUGH COMPRESSION OF AIR.

(*Field*, Nov. 28, 1896; Vol. 88, p. 878.)

LAST week we said that we hoped in our present issue to be able to give some further information relative to the action of compressed air in gunbarrels—our purpose being to show that the bulges and bursts which occasionally occur are due to the accumulation of force generated by the gradual but rapid compression of confined air, when the inertia of the obstructing mass cannot be overcome with sufficient quickness to relieve the stress in the barrel.

Messrs Rigby had criticised some remarks of ours as to the cause of a rifle barrel being bulged, and said that "the bulge is not in such a case caused by the compressed air between the moving body, whether wad or bullet, but by the powder gas in rear of the moving body when the latter is suddenly checked."

In our opinion Messrs Rigby's theory is erroneous. Near the breech, while the powder gases have their greatest expansive force and the air in the barrel has undergone little or no compression, the inertia of the obstructing mass may be gradually overcome—as the gas pressure is then at its highest point, while the air resistance is at

its lowest. When the distance between the breech and the obstruction is long, that condition of affairs is reversed: the force of the expanding gas becomes reduced, while the power of the condensing air is increased. The probability is that the advancing body never does come into actual contact with the obstruction, as the nearer the approach of the former the greater must be the compression of the air, and its consequent resistance.

When the obstruction lies near to the breech, the column of air would be very short; and the shorter it is, the sooner would it be compressed sufficiently to overcome inertia and impart motion to the obstructing mass; so that the movement of the advancing body and of the obstruction would go on simultaneously. But when the obstruction lies near the muzzle, the column of air being long, its compression would be comparatively slow at first, so that the advancing charge would have attained almost its highest velocity before it got near to the obstruction; and then, with the charge advancing at the rate of about 700 miles an hour, if it were in a shot gun, or double that speed in some rifles, it would be practically impossible for the obstructing mass to receive sufficient impetus to move forward at anything like a similar rate; and the air must undergo compression accordingly.

Even under the ordinary conditions of firearms, atmospheric resistance is by no means without effect in the barrel, as was shown by some experiments we carried out several years ago, in which the air was exhausted from a 12-bore gun by means of an air-pump, whereupon the muzzle velocity of a spherical ball increased 40 f.s. above what it had previously been; and at the same time the recoil of the gun was reduced, owing to the diminished work consequent on there being no air to expel from the gun. (See p. 204.)

In another experiment, which bears more directly on the present controversy, we took a stout 12-bore steel barrel, closed the breech by a strong breech-block, and, turning the barrel breech end foremost, fixed a temporary breech action on what had been intended to be the muzzle; then loading it with a cartridge containing 1½ drams of black powder and a steel bullet, which was an easy sliding fit in the smooth tube, the charge was fired. No injury was done at the thin end of the barrel, where the charge was fired, but at the thicker end, where there was only the force of the compressed air, the barrel was shattered at a short distance from the extremity, and the breech block, by which it was closed, was blown away with such violence that it could not be found.

In a previous article (see p. 225) we gave a diagram showing the pressures set up in the barrel with proof powders and various nitro-compounds. Now we give a somewhat similar diagram showing the curve of pressures produced by compressed air at different parts of the barrel, supposing the muzzle of the gun to be obstructed, and the air to be condensed by an advancing charge of shot. It will be observed that whereas, in the former diagram, the highest pressure of the powder gases was at the breech, and gradually diminished towards the muzzle, here the pressures are very small at the breech, and increase slowly at first, but there is a more rapid augmentation when the advancing charge has traversed about two-thirds the length of the barrel, and in the last few inches the increase is enormous.

The pressures represented by the curve are worked out from scientific formula framed for the use of civil engineers; and they are here based on the assumption that the obstruction is at the end of a 30in. barrel, and immovable, while the advancing body traverses a distance of 27in., commencing at 3in. from the breech. It also presupposes that there is a sufficient amount of force in the powder to produce the pressures stated; otherwise the advancing charge might simply stick in the barrel, without bursting it, as happened in some experiments we were trying several years ago with exceedingly large charges of shot, when the shot stopped about half way up the barrel, and the powder gases fired out of the touch-hole. (See p. 16.)

The principal diagram here given only carries the air pressure up to 2200lb., or about one ton. This occurs when the 27in. column of air has been compressed into the space of rather less than an inch; and while the charge is travelling one-third of an inch the pressure increases from 1000lb. to 2000lb. In the upper portion of the diagram—*i.e.*, above the point where the sudden diminution in breadth indicates the change from pounds to tons—is shown the stress arising from further compression; but it is on a different scale, with intervals of a ton instead of only 100lb. (This alteration of scale is merely for the purpose of saving space, as otherwise the height from 1 ton to 25 tons would be twenty times as great as here shown.) When the shot wad is one-twelfth of an inch from the obstruction, the pressure equals 25 tons per square inch—supposing, as before stated, that the obstruction is immovable and the barrel strong enough to withstand the stress; and before the shot could touch the obstruction the pressure would be infinitely greater.

So much for theory; and now we have some particulars to give with respect to actual pressures, as indicated by the crusher-gauge. In order to test Messrs Rigby's idea, the obstruction was placed at 24in. from the breech, and 3drs. of No. 4 powder (without wads or shot) was fired. The particles of powder gas rushed up the barrel, impinged upon the obstruction, and recorded an average pressure of 0·33 ton in six rounds, as shown in the following small table:

With 3drs. No. 4 powder only in cartridge.

	Tons per sq. inch.					Average.
At 24in. from breech	0·32	0·42	0·32	0·20	0·32	0·42=0·33

The next table shows the greater amount of gas pressure produced by the wad acting as a piston to compress the air. When 3drs. of the powder was fired with the usual wads, but without shot, the pressure recorded with the obstruction at 24in. from breech averaged 1·57 tons, as shown in the next table:

With 3drs. No. 4 powder and usual wads only.

	Tons per sq. inch.					Average.
At 24in. from breech	1·53	1·47	1·63	1·53	1·53	1·68=1·57

The obstruction (consisting of 1⅛oz. No. 6 shot and the usual wads) having been placed successively at the four plugs of the crusher-gauge, 3drs. of No. 4 powder, with 1⅛oz. of shot, was fired from the chamber, and the pressures given are shown below. That is to say, when the obstruction was at the 6in. plug the pressure set up was 2·95 tons; when the obstruction was at the 12in. plug the pressure was 3·50 tons; when it was at 18in. the pressure was 4·50; and at 24in. it rose to 6·34 tons, on the average of six rounds. But, although the obstruction was placed at these distances from the breech, it is of course impossible to say how far the shot had been pushed forward at the instant when the force was registered.

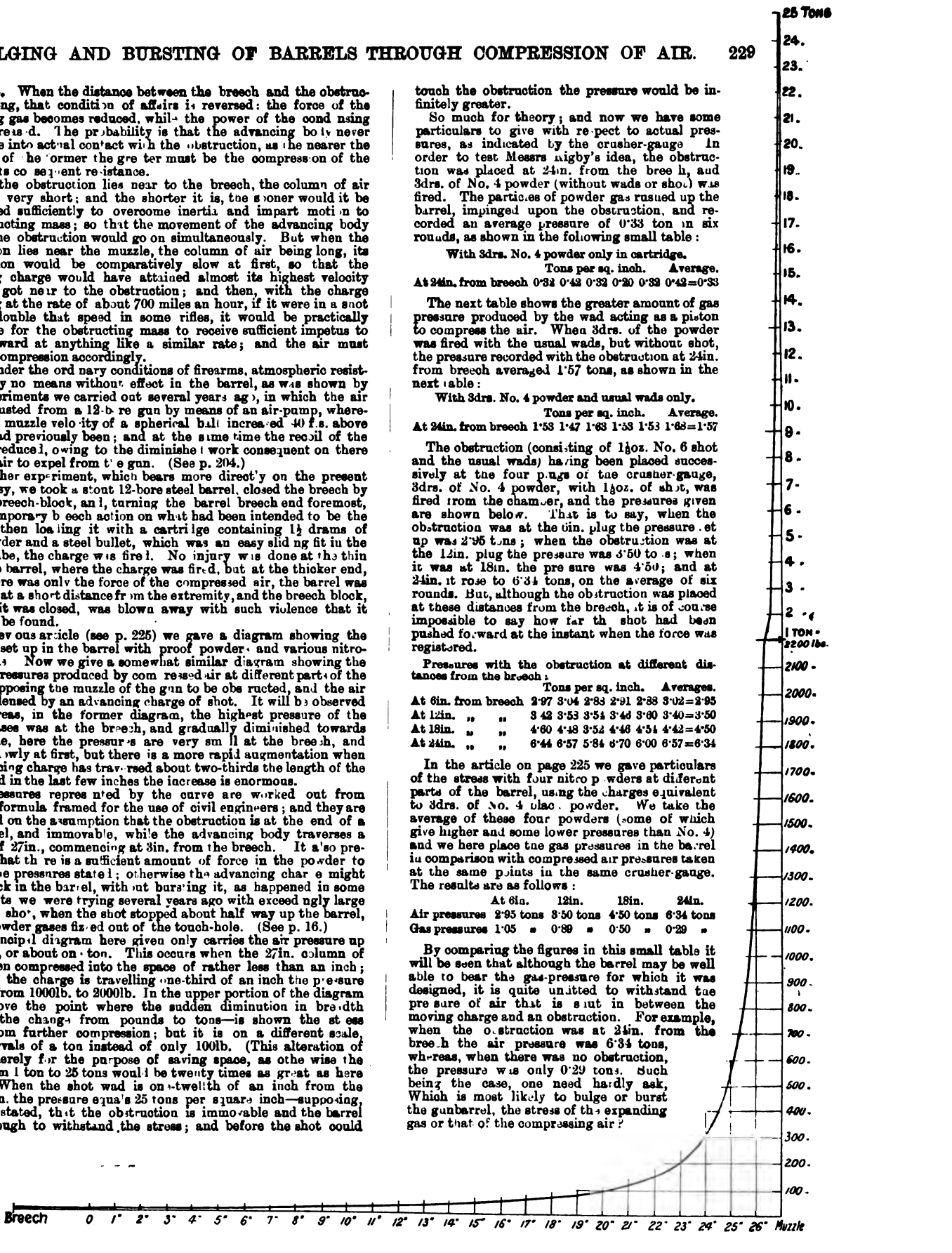
Pressures with the obstruction at different distances from the breech:

	Tons per sq. inch.					Averages.
At 6in. from breech	2·97	3·04	2·83	2·91	2·88	3·02=2·95
At 12in. „ „	3·42	3·53	3·54	3·46	3·60	3·40=3·50
At 18in. „ „	4·60	4·48	3·52	4·46	4·54	4·42=4·50
At 24in. „ „	6·44	6·57	5·84	6·70	6·00	6·57=6·34

In the article on page 225 we gave particulars of the stress with four nitro powders at different parts of the barrel, using the charges equivalent to 3drs. of No. 4 black powder. We take the average of these four powders (some of which give higher and some lower pressures than No. 4) and we here place the gas pressures in the barrel in comparison with compressed air pressures taken at the same points in the same crusher-gauge. The results are as follows:

	At 6in.	12in.	18in.	24in.
Air pressures	2·95 tons	3·50 tons	4·50 tons	6·34 tons
Gas pressures	1·05 „	0·89 „	0·50 „	0·29 „

By comparing the figures in this small table it will be seen that although the barrel may be well able to bear the gas-pressure for which it was designed, it is quite unfitted to withstand the pressure of air that is shut in between the moving charge and an obstruction. For example, when the obstruction was at 24in. from the breech the air pressure was 6·34 tons, whereas, when there was no obstruction, the pressure was only 0·29 tons. Such being the case, one need hardly ask, Which is most likely to bulge or burst the gunbarrel, the stress of the expanding gas or that of the compressing air?



CAUSES OF HIGH PRESSURES IN A BARREL CONTAINING AN OBSTRUCTION.

(*Field*, Dec. 5, 1896; Vol. 88, p. 892.)

SIR,—I have been very much interested in the correspondence and your remarks on the above subject, and was pleased to see you intended carrying out some experiments to place the matter beyond doubt. The results of the experiments in your last issue are interesting, but I submit they do not in any way define the actual cause. I would suggest that you made further experiments, taking pressures with an obstruction at different points along the barrel, but, before firing, exhausting the air from the barrel, or making the obstruction of such a nature so that there is a sufficient opening for the egress of the compressed air. In the meantime I should like, with your permission, to make a few remarks on the subject.

Whatever influence the air between the moving projectile and the obstruction may have, under certain conditions, on the bulging or bursting of barrels, it could have no influence on the bulged rifle noted in your issue of Nov. 7, because, the obstruction being a 16-gauge spherical bullet in a 12-bore gun, an area of $\frac{1}{100}$ of a square inch was left for the escape of the compressed air—an amount that could be easily shown to be sufficient to keep the pressures of the imprisoned air below half a ton; so that, in this instance at least, we must look for some other sufficient cause.

You have previously pointed out that the point of maximum pressure is an inch or more in front of the obstruction, and also that the distance between the projectile and obstruction is about or less than ¼in. when the pressure is about two tons. Consequently, the results of the experiments read as though the small length of imprisoned air had passed outside the range of the pressure gauge before the pressure of the compressed air had reached two tons. Mr Griffith has shown that, with condensed nitros in cone-base cases, the inertia of a shot-gun charge is overcome and moved 1 inch in $\frac{1}{1000}$ of a second, and we may reasonably say that the greater part of this time is occupied in igniting the powder, the inertia of the wads, shot charge, and turning over being overcome in something less than $\frac{1}{1000}$ of a second—an amount, I submit, as small as would be required to move an air-tight obstruction in the barrel without developing pressures above two tons. Moreover, if the imprisoned air were an important factor, the danger would be the greatest the nearer the obstruction is to the breech, because the time factor would be less, and also because, no matter how small the length of air compressed, the pressures would be infinitely great as the distance between the moving projectile and the obstruction became infinitely small.

I think there can be little doubt that the explanation of most of these bulged or burst barrels, due to obstructions, can be found and sufficiently explained in the wave of pressure of the products of combustion caused by the alteration in their velocity, consequent on the lessened velocity of the projectile as it carries with it the obstruction; and it is this dynamical problem, rather than theory, that requires mathematical investigation.

The total energy of the moving gases can be ascertained in a simple manner, and consequently the part of this energy destroyed by the wave set up due to a definite loss of velocity, but it is difficult to set down the maximum pressure during this adiabatic compression. It will take the form of: Maximum Pressure = (Constant) × (loss of energy due to lessened velocity).

The constant can be obtained empirically from the additional pressures set up by the obstruction, if we know the velocities at these points, and also the loss of velocity owing to the obstruction.

The loss of velocity in the experiments made was evidently one-half the velocity the projectile would have had at that point; as the projectile was of mass equal to the obstruction. The actual velocities of a charge driven by 3drs. of No. 4 black at different points along the barrel can be obtained approximately by plotting out a curve from Mr Griffith's records of its times in the barrel. Having determined these velocities, and by using the following formula:

$$P = 25\frac{W}{g}(V^2 - v^2)$$

Where P = maximum pressure
W = weight of powder charge.
V = velocity at point when there is no obstruction.
v = velocity at point when there is an obstruction.
g = 32·2.

We obtain the pressures in the following table:

	6in.	12in.	18in.	24in.
Velocity in round numbers	620 f.s.	920 f.s.	1100 f.s.	1400 f.s.
Measured pressures put on by obstruction (vide *Field*, Nov. 28).	1·90 tons	2·61 tons	4·00 tons	6·05 tons
Calculated pressures put on by obstruction	1·19 tons	2·63 tons	3·77 tons	6·11 tons

From the fact that a formula in the above form gives results proportional to those obtained by actual experiment, and that it also represents the nature of the pressure set up by the wave action, indicates that this wave theory is a true cause of the high pressures due to obstructions, and it now remains to make further experiments to put the matter beyond doubt. F. W. JONES.

Barwick, near Ware, Herts, Nov. 30, 1896.

[In our issue of Nov. 7 we expressed an opinion, founded upon the results of numerous experiments, that a 12-bore rifle barrel was bulged by the imprisoned air shut in between the cartridge (loaded with 6drs. of black powder, with a felt wad) and an obstruction near the muzzle, consisting of a 16-bore spherical bullet. Messrs Rigby subsequently stated that, in their opinion, the compressed air had nothing to do with the bulging of the barrel, but that the bulge was caused by the check given to the motion of the particles of powder gas. We carried out additional experiments, the results of which were published; and these results, in our opinion, proved that the bulges were caused by the compressed air, and nothing else.

Now Messrs Rigby's theory is again put forward by Mr F. W. Jones, who asserts that the imprisoned air shut in between a loosely fitting bullet and a cartridge would be powerless to cause a bulge, and it, in his opinion, the wave of pressure set up in the powder gas, when the motion receives a check by meeting the obstruction, is alone answerable for the damage done to the barrel.

The ideas enunciated by Mr Jones, we take it, are purely theoretical, because he does not say one word about any experiments that he has carried out. In this connection we may remark that there is scarcely a day passes but that some pet theory has to go by the board, swept away before results of practical trial.

However, since the receipt of Mr Jones's letter we have carried out further trials in the hope of convincing our correspondent that he is in error. We first repeated, as nearly as possible, the experiment originally made with the bulged rifle, *i.e*, by placing at the 24in. plug of our 12-bore crusher-gauge a 16-bore spherical bullet, and then firing a cartridge loaded with 6drs. of No. 6 black powder and a ⅞in. felt wad. The pressure recorded was 2·25 tons square inch; whereas, according to Mr Jones's theory, it should have been below half a ton. This, we venture to assert, completely settles that part of the question.

In order to again put to the test the wave theory brought forward and supported by Messrs Rigby and Mr F. W. Jones, we loaded the 12-bore crusher-gauge with a cartridge containing 3drs. of No. 1 T. S. Black powder and a ⅞in. felt wad. The grain of this powder is extremely fine, and the explosion very rapid. Hence, if it were possible to produce any "wave pressure," it would be most likely to result from the use of this rapid explosive. Mr Jones, in the first paragraph of his letter, suggests that we should make "the obstruction of such a nature that there is sufficient opening for the egress of compressed air." We have accordingly done so. The obstruction consisted of a round steel rod 7-16ths of an inch in diameter, 7ft. long, and weighing 5lb. The end of this rod was inserted in the muzzle of the crusher-gauge to such a distance that on the cartridge being fired the felt wad struck the end of the rod at the instant the wad passed the 24in. plug; so that, whatever wave pressure was set up, the plug was in the best position to record it. The steel rod had only a sectional area of ·1503 sq. in., thus leaving an area of ·2682 sq. in. for the escape of the air past the obstruction. When the charge was fired, the felt wad struck the end of the steel rod and the pressure recorded was only ·91 ton per square inch. Of course, the whole of this pressure, small as it is, was not due to the wave set up—a portion of it being caused simply by the pressure of the powder gases. We consider these experiments conclusively prove that the damage done to gunbarrels, when there is any obstruction to the motion of the charge, is caused by the imprisoned air, and not by any wave pressure set up in the powder gases.

We may add that "wave pressure" is a phrase that has been coined to account for irregular pressure in big guns when use is made of a fine-grain quick-burning powder that is unfitted for use therein. The phrase is quite out of place when referring to small arms.—ED.]

(*Field*, Dec. 12, 1896; Vol. 88, p. 931.)

SIR,—May I suggest that a bulge in a gunbarrel is caused probably by the great elasticity of air? This at first sight may appear paradoxical, but we must bear in mind that the column of air in a barrel is not pushed out as a column of air in its normal state. Owing to its great elasticity, it is, so to speak, rolled up and compressed immediately in front of the charge rapidly advancing. In this compressed state, and rapidly advancing at great velocity, it is easy to conceive that the slightest obstruction—even if not filling up the whole space—is sufficient to give suddenly an enormous pressure, amounting

practically to a blow, there having been no time allowed to impart motion to the obstruction.

Wave-pressures are simply irregular pressures caused by irregular rates of ignition given by an unsuitable shape of grain. The great offenders are the large cubical powders; and I think the reason is obvious. The e evenly-made cubical grains can place themselves in the charge either flat side to flat side, thereby giving little passage for the igniting flame, or they can arrange themselves so that their angles come in contact with other grains, giving a very free passage for the flame. In one case you will have slow ignition and low pressure, in the other very rapid ignition and high pressure, which becomes more or less a matter of chance.

Theoretically, the sphere is the best form of grain for even ignition, and consequently even pressures; but an irregularly shaped grain, giving an average of about the same passage of flame, by the rule of chances should, and does, give a more even pressure than the cubical grain of the same approximate size. M. T.

(*Field*, Dec. 19, 1896; Vol. 88, p. 997.)

SIR,—I have to thank you for the insertion of my letter in your issue of Dec. 5, and also for your remarks on the same, and I trust you will keep the matter open in your columns until the question of bulging and bursting of gunbarrels owing to obstructions has been discussed from every point of view, and a cause satisfactory to your readers arrived at.

My letter must have fallen very much short of the intention if it conveyed any theory. I am perfectly indifferent whether the imprisoned air, or the wave in the products of combustion, is the more powerful cause; they present to my mind dynamical problems requiring mathematical investigation rather than theories In any case, the correct cause will allow of theoretical demonstration, if we can get at all the influences at work, and in the meantime we may disregard any hypothesis which is obviously not in accord with well-known mathematical laws.

I quite agree with you that every day so-called theories—or what I prefer to term "formulated seemings"—of practical men are being swept away by the light of more careful observations, but this should not deter theoretical investigations or explanations; it only points to the need of more careful observers.

To my mind your experiments up to now do not conclusively demonstrate which of these two causes has the most influence on the damage done to gunbarrels containing an obstruction. One experiment in your issue of Dec. 5, points to wave action, as I will show below; but there are experiments suggested by theoretical considerations which will demonstrate whether the imprisoned air is an active cause, and in the near future I propose to carry out such tests, and shall be pleased to let you have the results.

Pardon me for disagreeing with you that "wave pressure" is a phrase coined to account for local pressures in artillery firing small-grain powder. As a matter of fact, it is a physical sequence that has always been taken into account where gases in motion are under consideration. In bomb experiments special precautions are necessary to guard against these abnormal pressures, and in small arms it is necessary to bear it in mind.

As I said before, it is difficult to set down the maximum pressure in the wave of the products of combustion, but it is a simple matter to put down the maximum pressure of the imprisoned air during the setting in motion of an obstruction of known weight, and giving to it a definite velocity. In the adiabatic compression of a volume of air, the work done during the passage from pressure P_1 to P_2 is represented by

$$\frac{P_1 V_1}{\gamma - 1}\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - \frac{P_1 V_1}{\gamma - 1}$$

where V_1 = the original volume, and
γ = 1·408, the ratio of the specific heat at constant pressure to that at constant volume.

And this will equal the work done on the obstruction, viz.:

$$\frac{w}{2g} V^2$$

where w = the weight of the obstruction.
V = the velocity given to it.
g = 32·2, the accelerative force of gravity.

For the case where the obstruction was an ordinary charge of shot and wads in a 12-bore at 24in. from the breech, and the cartridge was a usual 12-bore No. 4 black, the maximum pressure comes out at 21571b., or practically 1 ton, and the distance between the moving mass and the obstruction would be at that moment 1·3in. The calculation is based on the assumption that the obstruction does not move until the energy $\frac{w}{2g} V^2$ has been put into it, but of course the obstruction will have commenced to move and have reached its maximum velocity at the moment of maximum pressure, consequently the pressure figured above will be considerably in excess of the real—an amount that could be estimated by further mathematical analysis.

It is different in the case where the obstruction was a 16-bore spherical ball in a 12-bore barrel. Here the aperture for the escape of the compressed air was ·0732sq. in., approximately $\frac{1}{14}$ of the area of a 12-bore, and the velocity of the efflux of a gas under pressure is represented by about $1300\sqrt{p}$ foot seconds, where p equals the pressure in atmospheres. From this it is obvious that, with a velocity of the projectile of 1300 ft.sec., the maximum pressure of the imprisoned air cannot be greater than $\left(\frac{57}{10}\right)^2 + 1$ atmospheres, or ·22 tons. But you obtained 2·25 tons; and, if this were due to the imprisoned air, the time has arrived when we should sit down to rewrite the laws of motion. It is to my mind a further proof that in this instance the 2·25 tons was due to the wave pressure of the products of combustion, and that it was this wave that bulged the barrel. Yet I am prepared to find that the imprisoned air might have an influence on bulging barrels under certain exceptional conditions. F. W. JONES.

Barwick, near Ware, Herts, Dec. 7, 1896.

FURTHER EXPERIMENTS.

[As promised in our last issue, we have carried out further experiments, with the result that we are more fully convinced than before that, when there is an obstruction, it is the compressed air which causes bulges in the forepart of gunbarrels; and that the surmises which have been brought forward by Messrs Rigby and Mr F. W. Jones are erroneous.

We took our 12-bore crusher-gauge, which is 30 inches in length, and screwed an air-tight steel plug into the muzzle. This plug was fitted with a prolongation exactly the size of the bore, and reaching to within three eighths of an inch of the 24-inch plug. The air was then exhausted from the barrel by means of an air-pump, and 6drs. of powder were fired, with a felt wad, but no shot, in order to ascertain what statical pressure would be produced by the powder alone; and this, taken at the 12-inch plug, was found to slightly exceed 1 ton per square inch.

The air having been again exhausted from the barrel, a similar charge of 6drs. of powder and a $\frac{3}{4}$in. felt wad was fired, and the pressures were taken at the 24in. plug—the best position to record any increase of pressure caused by the sudden stoppage of the powder-gases or wave-action. The pressures recorded averaged 1·35 tons; so that the whole of the additional pressure due to the stoppage of the powder gases, or wave action, was about one-third of a ton. That is to say, such was the difference between the statical pressure, and the total result produced by wave pressure being added to statical pressure.

We then repeated our former experiment, with the 16-bore spherical bullet in a 12-bore barrel; and again obtained a pressure of 2·25 tons, as caused by the compressed air shut in between the powder charge and the obstruction—or nearly a ton more pressure from the compressed air than was produced by the powder-gases and wave-action.

The most conclusive experiment—which, to our mind, must carry conviction to any unbiassed person was as follows: An ordinary 12-bore shot gun was taken, and an obstruction (consisting of 1½oz. of shot between two wads) was placed at the muzzle. The charge fired was one dram of No. 6 black powder, and the projectile was an accurately-fitting piece of very hard wood, 6in. in length, with a $\frac{3}{4}$in. soft felt wad at each end of the projectile—the one to prevent the passage of air, and the other to act as a similar check on the gases. The walls of the barrel were stronger nearer the muzzle (where the obstruction was placed) than they were at six inches nearer the breech. If the theory brought forward by Messrs Rigby and Mr Jones were correct, the result would be that the barrel would bulge or burst at the full length of the projectile from the obstruction—*i.e.*, where the motion of the gases received the check—or in other words, at six inches or more from the muzzle. If, on the other hand, our contention were correct, the burst would take place close to the obstruction, or little more than one inch from the muzzle, where the compressed air was at its greatest pressure. This is what really happened: The side of the barrel was torn out for an inch in length by the compressed air close to the obstruction, whereas at the other end of the projectile no sign of injury to the barrel could be perceived.

Messrs Rigby can easily prove this by trying the experiment on one of their own guns. Mr Jones appears to be of opinion that all problems relating to gunnery may be solved by mathematical analysis. To prove what a rotten reed mathematical analysis alone is to depend upon, we will take Mr Jones's own example. He states that, with a pressure of one atmosphere, the velocity of the efflux of gas or air is about 1300 feet per second. This is only approximately true under exceedingly small heads of pressure, and when the orifice, through which the efflux takes place is shaped to the form of a contracted vein. Now, when the efflux takes place through an orifice in a thin plate (conditions very similar to the air flowing past a 16-bore bullet in a 12-bore barrel), the efflux is only about six-tenths of that which theory says it should be. Furthermore, as the pressure increases, the velocity of efflux is exceedingly small in comparison with what theory would specify—the cause of this difference being the rapid expansion of the fluid at the instant it has passed the orifice; which expansion has the effect of keeping back the issuing stream.

Mr Jones's mathematical calculations are based upon a formula which at one time was supposed by mathematicians to be applicable to the efflux of all fluids, but which has since been proved to be totally inapplicable to elastic fluids such as air or gas. We would recommend a study of the records of the masterly experiments carried out by Mr George Wilson, C.E., and published in *Engineering*, vol. xiii., 1872.

We have given a great deal of time and space to this subject, and, if any of our readers remain unconvinced, we shall be willing to publish positive evidence when any is produced to support their contentions; and until then we must, after giving the letters in our present issue, stop further controversy on the subject.—ED.]

(*Field*, Dec. 19, 1896; Vol. 88, p. 997.)

SIR,—In this controversy an essential condition of the original accident has been lost sight of. The bulge in the 12-bore rifle barrel was caused by a 16-bore bullet, which had been jerked forward by the recoil of the right barrel, and, as you describe it, "rolled" some distance up the bore of the left. We have only to compare the diameter of a 16 bullet with that of a 12-bore barrel (taking also the depth of the rifling into account) to perceive that the conditions are widely different from those in most of the experiments on which you rely. In the latter the obstruction is generally a charge of shot between wads, more or less air-tight, and also of a nature such that any attempt to set it in rapid motion would expand it, set up much friction or ramming, and render it still more gas-tight. In the case of the 12-bore rifle, we cannot see how the air between the moving wad and loose bullet could have reached the tension necessary to bulge so strong a barrel. It seems to us that this free passage of air past the loose bullet prevented a sufficient compression of it, and so the wad and charge struck it while still inert.

The adiabatic curve of pressures in yours of Nov. 28 represents the proportion between the volume of a gas and its pressure, when no heat escapes during its compression by an external force. The gas is passive. The active force is that which drives the piston forward, and if this force be another gas at the back of the piston, then the pressure behind the piston must, along with the momentum of the latter, be greater than the resisting pressure of the confined gas. Apply this to the case of Mr Griffith's pressure-gauge gun (see yours of Nov. 21), a very high pressure would be required to bulge such a barrel. Let it represent the closed tube, and the moving charge of shot the piston, then, before the air in front reached the tension of 25 tons, it would have been compressed into a disc only one-twelfth of an inch in thickness. This disc (assuming the diameter of the barrel to be ·7) would press against the obstruction with a force of 9·6 tons, and radially against the barrel with a force whose total would be only 4·4 tons.

Returning to the adiabatic curve, the force which compresses the air in front of the charge is the expansion of the powder gases. These do not, however, increase in intensity of pressure as the charge moves up the barrel. Where, then, are we to look for a sufficient force to cause a bulge through air pressure? Possibly in the momentum of the piston, which, in this case, is the charge, including its wadding, &c. In other words, when the obstruction is near the muzzle it is not possible to compress the air to a sufficient tension without considerable momentum having been imparted to the piston, and sufficient weight *in* the piston. In your experiments described on the 5th, you got over 6 tons when the piston is a charge of shot with its wads, but only 1·57 tons when the piston is a wad only. The inevitable conclusion is that the compressed air, when it exists, is only the passive medium conveying to the barrel the energy of the powder gases, and whenever a barrel is bulged or burst by reason of an obstruction, there exists in the moving charge (whether a cushion of air be before it or not) sufficient energy to effect the mischief.

We cannot think your experiment with the steel rod at all conclusive. It did not present sufficiently the case in point. The wad would be punched by it and blown out without much obstruction; moreover, a charge of 6drs. was used when the rifle was bulged, and only 3drs. in this experiment. We suggest to dispose of this case of the 12 bore rifle that you try the following: Instead of a bullet, place in the bore a piece of lead tube, say 1in. long, with a bore of 0·4in. at the end towards the breech, and widening so as to permit free passage of the air, but obstruct the wad, &c., for which purpose it should be jammed in the barrel, then fire a charge of 6drs. as before.

We think you do not assign their proper importance to wave-pressures in the powder gases. Suppose the projectile arrested near the muzzle, the stream of gas and other constituents of the charge that are following it up the barrel at various velocities are suddenly checked and crowded into the space next to it, then a reaction must take place, and waves of alternate density and tenuity rush from end to end of the space until the whole comes to rest. There are other kinds of bulges that occur in rifle barrels in which there is no obstruction; these are caused by the bullet slipping forward, sometimes not more than a few inches, yet with full charges of powder bulges often result.

With respect to one other of your experiments, viz., when you fired a steel bolt up a barrel from the muzzle, the breech being closed, and the breech was shot away, do you suppose that this would not have occurred if there had been a hole to let the air out and the steel bolt had struck the breech with its full velocity?

JOHN RIGBY AND CO.

[With respect to the question asked in the concluding paragraph of Messrs Rigby's letter, we may say that we do not believe the breech would have been "shot away" in the same manner as happened in our experiment. But the words used by Messrs Rigby do not appear to us to convey the same idea as we endeavoured to express by saying: "At the thicker end, where there was only the force of the compressed air, *the barrel was shattered at a short distance from the extremity*, and the breech-block, by which it was closed, was blown away with such violence that it could not be found." As nearly as we can tell (not having taken an exact measurement at the time), we should say that the last two inches of the barrel were destroyed, which would not have happened if the steel projectile had met with nothing but the breech-block. As to the other experiments which Messrs Rigby suggest that we should try, we can only suggest that they should try the experiments for themselves, and thereby endeavour to prove the accuracy of their own conclusions.—ED.]

(*Field*, Dec. 19, 1896; Vol. 88, p. 997.)

SIR,—While I have no doubt but that the sudden compression of air between an obstruction in a barrel and an advancing discharge of shot is sufficient to cause a burst or bulge of said barrel, I incline to think that the retardation of the shot must tend to set up some increase of pressure in the powder gases. Such increase might be noted at the 18in. plug when the obstruction is about the 24in. plug, and compared with the normal pressure there in a clean barrel void of obstruction.

Your results give evidence of the prime influence of the projectile in elevating the pressures when an obstruction is present. The query arises, does the weight of the projectile or its length, or both, determine the extent of the air pressures?

In overcoming an obstruction in a 12-bore, your results give the pressures following:

With cartridge of powder, wads, shot	6·34	tons per square in.
" " powder and wads	1·57	" "
" " powder only.....	0·33	" "

The pressure in a clear barrel with complete cartridge is slightly under the last (0·33 ton) figure, being 0·29 as the mean of four nitro powders.

The effect of the wads in raising pressures is eclipsed by the multiple effects of the wads and shot. The latter presumably ought to travel slower up the barrel than the light wads, and so give a less sudden, if more irresistible, blow than the wads alone, which from their greater compressibility would tend to absorb some of the pressure, and thereby relieve the duty on the plug gauge. You claim to have proved that the compressed air is the cause of bursting the barrels; but, on reading over your data, the wads and shot caught between two pressures—before and in rear—would seem to have a right to be considered as possibly more directly concerned with the mischief than the initial compression of air. If the shot caused a bulge there might be much "balling" produced, which could be seen if the shot were caught and examined after quitting the bore. Much of the above you have doubtless determined, but, as no record appears in your columns, I have ventured to point out these problems.

36, Earlsfield-road, S.W., Dec. 13, 1896. GEO. H. HOGIS.

TESTS OF THE STRENGTH OF GUNPOWDERS.

Visit of the Gunmakers' Association to the Schultze Gunpowder Factory.

(*Field*, July 4, 1896; Vol. 88, p. 3.)

Through the courtesy of the Schultze Gunpowder Company, about eighty members of the Gunmakers' Association were enabled to spend a very pleasant day in visiting and inspecting the Schultze Gunpowder Factory a few miles from Lyndhurst, Hants. These works, beautifully situated in the heart of the New Forest, consist of sixty separate houses, covering a large area of ground and giving employment to upwards of 100 persons. The members were taken from Waterloo by special train to Totton, the most convenient station for the works, and thence to the factory in brakes, making a *détour*, whereby about a dozen miles of the prettiest scenery in the forest might be enjoyed. Upon arrival at the factory the members were regaled with an excellent lunch, and afterwards conducted in separate parties through the different houses, the various processes in the manufacture of the powder being thoroughly explained. This having been accomplished, Mr. R. W. S. Griffith, the company's manager, delivered a highly instructive lecture, an abstract of which we publish below. After the lecture tea was served, followed by the inevitable photographing, the object of which presumably was that in the dim and distant future the members would be able to recall the happy and intelligent expressions which their countenances wore on this auspicious occasion.

The Lecture.

Mr. Griffith said that in the programmes given them by Mr. Baker they would see that he had been put down to deliver a lecture. That was a very elastic term, and gave him a wide margin as to the style of remarks he should address to them. He believed that he had been asked to do this in order that he might be able to give them a little information as to the various things that had come across him in the way of experience in regard to the smokeless powders. He thought he could not do better than give them a little description of the evolution of the present method of testing powder; for he happened to take up the work at a time when the whole science of estimating the actual force of gunpowder was on the change, and he had been through the whole series, which by a course of evolution had led up to the adoption of the present methods. He should therefore speak to them on the history of the evolution of the present methods of taking the strengths of gunpowder, and so fulfil the object Mr. Baker had in view in asking him to address them that afternoon.

Formerly the black powder makers depended upon the recoil effects for estimating the strength of the stuff they had to deal with. But naturally enough, when a new explosive came into the field that had a different degree of recoil and a very different action producing the recoil, the old process for taking the strength by means of recoil was perfectly useless. He first began to measure these effects now something like twenty-three years ago. He took his first stand on penetration.

Penetration in those days was a very strong point; and it would be interesting here to mention some of the methods he had tried, to get regular results by penetration. For some years he worked at the problem as to how to take the actual penetrative power of the shot—the Pettitt pad, cardboard, strawboard, and all sorts of paper targets. Movable targets on wheels, levers by pendulums, seemed promising, but failed. Tin, copper, and lead sheets were all tried. Soft material such as cork and paraffin wax had their turn; and another line that promised to give satisfactory tests was tried, but utterly failed—the so-called water target. The end of it all had been that, so far as penetration was concerned, the opinion had been arrived at that in attempting to estimate the strength of the powder by the penetrative force of the shot, they had begun at the wrong end. It might be a very good plan for the gunmaker to try the penetrative force of his guns, but the maker of the explosive itself had made a mistake, and many years had been wasted in attempting to estimate the force of his gunpowder by the penetrative force of a charge of shot. He had found it was all a mistake, and of late years he had come to what he thought was a far more satisfactory conclusion, so far as explosives makers were concerned, with regard to estimating the strength of the powder. He considered that could be much better ascertained by the action that took place before the projectile left the gun, or immediately after. It depended so largely on the gun itself what the penetrative effect would be at 40 yards; but the effect inside the gun depended so much more on the explosive or ammunition used. The explosive maker must look more to the effect produced inside the gun; the gunmakers could find out for themselves more of what took place at the other end.

Even in those early days when he was working away at penetration he did not entirely neglect internal pressure. In fact, it was a point that could hardly be disregarded. There were in those early days of Schultze gunpowder certain guns, which, to say the least, were not up to the best standard; and, on the other hand, Schultze was not adapted to some of the weapons. The consequence was that the action of Schultze in the gunbarrel was brought home to them in a way not at all pleasant. He then began to inquire into the internal action of the powder and the internal pressure. The first method he used was this. He procured gunbarrels which he had made to a certain gauge and strength. He put them through a series of proofs of his own, and tested them to know what quantity of black powder they would stand. He used them with large charges of his own powder, and rejected the powder when it damaged the gun. That was a rough-and-ready way of doing it; but it had a few bad points about it, inasmuch as, at a time when one least expected it, pieces of the barrels would be flying round and about him in a most uncomfortable way. As time went on, he resorted to other methods of taking the internal pressure that did not have the same knack of throwing fragments about

In the year 1875 they began taking velocities by a chronograph, and those of them who followed the publication of the results in the *Field* would remember that he published a good many tables of velocities at different times. The first velocities he used to take in the Snider, which, with the old sawdust Schultze powder, used to give some exceedingly good shooting; although the same powder was useless in the Martini. But when he turned to the velocities of shot, many difficulties arose. Although it seemed so simple now, when they saw what they ought to have done, yet it took a lot of experimenting before they obtained good readings. Those of them who had been over the gun room would have noticed the Boulengé chronograph, by which the velocity of a charge of shot in travelling from the muzzle to a given distance was ascertained by measuring the relative distances that two dropping weights fell during the period. The difficulty which caused most trouble arose from the so-called "stringing" of shot, which gave varied readings as the first arrival or body of the charge was recorded. This was overcome, he thought perfectly, by the use of his sectional target, which they had seen in the long shooting range. By its means no register was made until the main portion of the charge struck the plates simultaneously. With the Boulengé chronograph of this target very good results were obtained at the long ranges. But this chronograph, like all those made on the falling principle, was liable to considerable residual magnetism, which, of course, was calculated to upset any fine readings. Moreover, air resistance and altitude are not taken into account. In consequence *this* chronograph only measured true to a thousandth part of a second.

A more accurate chronograph was required for work inside the gun; and with the Smith's chronograph they were able to measure to the hundred-thousandth part of a second. With such an instrument as this, very close readings could be obtained; and now he was in a position to attack the problem of what happened inside the gun at the moment of firing. The accompanying table would give some idea of what actually were the times of travel.

The velocity power of guns had gone on steadily increasing of late years. The average velocity of a gun at 40 yards, No. 6 shot, in 1878 was 840ft.; ten years later it had gone up to 855; and now it was 870 to 880. They could look forward to the time when the average shot gun would give a 40 yards velocity of 900ft.

Time Taken in Travel of Shot in a 12-bore Barrel at Various Points, by a Smith Chronograph, in 100,000ths of a Second.

	From cap to 3″	3—6″	6—12″	12—18″	18—24″	24—30″	Total time in barrel. Second.
Black No. 2	72	45	55	45	35	30	·00282
Black No. 4	138	52	61	50	40	34	·00375
Black No. 6	162	55	65	56	45	37	·00420
Schultze.....	275	46	57	48	40	34	·00500
Condensed, in the coned case.....	72	44	57	48	42	37	·00300
Condensed, in the ordinary case...	100	45	58	49	42	36	·00329

Leaving velocity for a moment, and returning to internal pressure, it was necessary to get something definite about that. He had on the table before him his first barrel used in ascertaining the pressure. It was a very crude arrangement, and it acted towards the last almost disastrously, as, on account of a breakage, a plug flew across the room, and only just missed him. Although the instrument was very crude, yet the general facts he was able to work out from it had never been

upset by means of any other more modern contrivance. A few years after this he had a 12-bore pressure gun, with plugs for lead crushers made, and also a 20-bore, and with these he had worked from that day until this. Although the more modern apparatus, with small plugs, was more desirable for ordinary work for gunmakers, he preferred his own, with the larger plug, for testing the explosive itself in factory manufacture.

He bore willing testimony to the regularity and excellence of the crushed leads as now supplied by Messrs Eley; true to dimension and to weight, they were very reliable, and the calculated pressure per square inch was probably very near the truth. Mr. Griffith then explained the action of the Smith chronograph, in which a style, released by breakage of electrical current, traced a line on a rapidly moving smoke glass, which also received the beat of a tuning fork. One great point about this instrument is, it could be put into operation at very short notice: the readings are made very quickly; and with it the time elapsing between the fall of the hammer and the arrival of the charge at the muzzle, could be measured with exactitude in four or six different sections along the barrel. Having got a chronograph of this character, it was necessary to get a gun which would give them the knowledge they wanted, and for that purpose he had the one made they saw before them. It is a 12-bore, perforated through the barrel with exceeding small holes at 3in., 6in., 12in., 18in., 24in. from breech. Connection was made through these with capillary glass tubes filled with mercury; and as the charge of shot advanced down the barrel these were successively fractured and a registration of time made. By means of such a gun he was able to tell much of the character of the explosive used. They could take it for granted that the powder must start on its own travel within a certain limit; but if, having once started, it hangs in its steady progress anywhere, they could safely come to the conclusion that there was something wrong with it. And this test, coupled with pressures given by lead crushers at the same points, enabled him to correct pressure by time, and to arrive at the true result. He should like at this moment to direct their attention to the following table, as showing how the different powders came out under such a test. He drew their attention to this table as he thought it would be interesting to them to know the effects produced by various powders. He now came to the table of pressure tests with the lead crusher in the plug gun. A series of crusher-gauge served to measure the pressure at various points along the barrel. He had prepared a table in regard to these tests, and here it was:

TABLE OF PRESSURES IN A 12-BORE BARREL, IN TONS PER SQUARE INCH, TAKEN IN LEAD CRUSHERS AT:

	From breech.						
	1″	2½″	6″	9″	12″	18″	24″
Black No. 2.....	3·16	2·90	1·42	1·28	1·25	1·25	1·15
Black No. 4.....	2·60	2·40	1·45	1·28	1·25	1·25	1·20
Black No. 6.....	2·15	2·04	1·55	1·40	1·28	1·28	1·25
Schultze	2·55	2·62	1·48	1·30	1·25	1·25	1·20
Condensed, in the coned case	2·10	2·25	1·50	1·25	1·20	1·15	1·05
Condensed, in the ordinary case ...	3·45	2·56	1·50	1·25	1·20	1·15	1·05

What they as explosive manufacturers wanted to know was the strength of the powder in the gun, and for the first 5 yards. It was very largely a gunmaker's question what happened at the 40 yards. They could take a certain powder and try it in fifty guns at the 5 yards, and the velocity would only slightly vary; but at the 40 yards range it depended very largely upon the gun they used as to what the penetrative effect would be. In conclusion, he should like to say one more thing with regard to a certain class of "cranks" who were well known to both gunmaker and ammunition maker. Sometimes they received a letter from such people after this style: "Dear Sir,—Your powder is utter rubbish. I fired three shots against a tin canister without making the slightest penetration." They found certain "cranks" like that in the explosive trade also. He made bold to say that, even if the gun and explosive making had not reached an actual science, it had reached very near to it, when it was considered that to get a certain result from a certain gun, with a certain powder, it was necessary for so many things to be regularly true—such as the primer, the size flash-hole, the stiffness of tube, the turnover, the charge, the wadding, the bore of gun, and the mainspring, everyone of which might affect the actual result. And knowing all this, and that there is such splendid regularity nowadays in shooting results, he could not help saying that the productions in the present day, of the gunmaker, and of the ammunition maker, and of the explosives maker, as they were supplied to the public, were a credit to everyone concerned.

MR. GRIFFITH ON SHOT-GUN PATTERNS.

UNDER the auspices of the Gunmakers' Association, Mr. R. W. S. Griffith, the superintendent of the Schultze Gunpowder Company's Factory, delivered a lecture on April 26, 1897, at the Royal United Service Institution. Owing probably to the short notice given of the time and date, the attendance was not so numerous as would otherwise have been the case; still, a large number of gunmakers were amongst the audience, as well as many well-known experts in the science of gunmaking and its allied trades. The chair was occupied by Mr. H. A. A. Thorn (better known to the general public by the name of "Mr. Charles Lancaster," of whom he was the pupil, and now is the successor); and in his introductory remarks he referred to Mr. Griffith's many researches already published, and to the debt the gun trade owed him and other experimenters, by whose efforts many of the problems connected with guns, powders, and caps were being solved, and the tabulated knowledge of many branches of explosive and gunpowder work was vastly increased.

A summary of this lecture was published in the *Field* of the following Saturday; but a much more complete report was given in the pages of our monthly contemporary *Arms and Explosives*, and was subsequently reprinted in pamphlet form by the Schultze Gunpowder Company. We have accordingly asked Mr. Griffith's permission to reprint his lecture in full, with the illustrations, and now reproduce them below:

NOTES ON PATTERNS.

I have before this been pleasantly twitted with the fact of endeavouring to accomplish the impossible; and I feel I may certainly lay myself open this afternoon to some such charge in trying to interest for an hour a body of technical gentlemen on the question of Patterns. It is a very wide subject; and to any who have walked many miles, and spent many hours in that most monotonous of gentle exercise, the trotting from the firing end of a 40-yard range to the whitewashed plate at the other end, and the counting of the pellet marks awaiting his approval or his disappointment—one that does not awaken the most pleasant of memories—I would suggest that were a new form of punishment needed for a first-class misdemeanant, the faithful carrying out of a fair series of shots (say two thousand), and pattern-counting at the 40 or the 60 yards range, would about suit the case.

I can only ask you to pardon any failure of interest, or omission of points that may occur to you as essential ones, while I do my best; and if I fail, I can but say that I am not altogether to blame for your disappointment. When I was asked to undertake an evening on shooting matters, I undertook to try to do so if the subject were set for me. The fatal word "Patterns" was at once uttered, and I knew my fate; but having made the promise, I will endeavour to redeem it, and cast myself on your indulgence.

For more than twenty years I have been diligently observing shot-gun patterns, and naturally have gained a good deal of information on this subject, which will act as a foundation for my remarks to-day; but in order that I might give to the results I hope to show you the benefit of latest experience, I have taken a special series of about a thousand patterns for this paper. I do not propose to show you anything especially fine in the nature of the patterns, but merely good average specimens of average loadings, and for this end these cartridges were loaded in the same careful manner in which they are now turned out by the million for trade purposes and not with the extra precautions necessary to be taken when one of the other points of explosives has to be considered more carefully. I have not used selected cases, wads, or appliances, but merely those in the condition and usual form found in the loading-room.

I do not expect there will be much, if anything, in my remarks this afternoon to give rise to a discussion—indeed, my fear, on the other hand is there will be such an absence of any new matter, that no point for discussion will be introduced; but I shall only be too pleased to reply to any point that is raised, as far as I am able to do so.

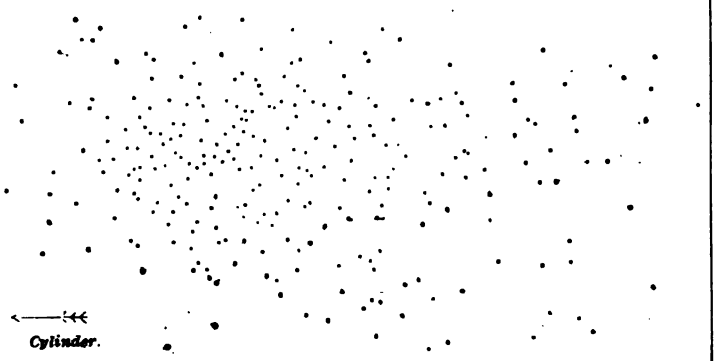
I propose to speak first on the theoretical formation of a "pattern," and then to show practical illustrations of such theories.

First.—As there may be one among this audience who may say what do you mean by "pattern?" I would reply, it is the appearance of the marks made by the pellets of shot fired from a shot-gun at any distance at right angles to a flat surface—usually hard and whitewashed, sometimes soft and yielding—so that each pellet makes a distinct splash or mark, or perforation, easily observed. It tells us roughly the angle of flight which each pellet has taken on leaving the muzzle of the gun, some indication of the action of the explosive in the gunbarrel, and chiefly whether the flight of shot can fulfil its purpose—that of striking with one or more pellets the object fired at.

It does not show, however, the actual form which the flight of pellets assumes before it strikes the target; for this, very special appliances are required.

"Pattern" is probably to the gunmaker the most important of the four chief points, attention to which results in perfect shooting from the gun; but to the powder-maker it occupies the fourth place. The first being a safety pressure in the barrel, the second the velocity of the shot, the third the rate of ignition and combustion in the barrel, and the fifth the gun recoil.

The importance of "patterns" arises in this way—the ideal shot would require one projectile only, suited to the size of the game; but two things make this a general impossibility. One is the slight variation in time occupied from the fall of the hammer to the arrival of the projectile at its mark; and this is the point which generally carries the abuse when a miss happens. The chief reason is, however,



STRINGING OF SHOT AT 30 YARDS WITH CYLINDER BARREL.

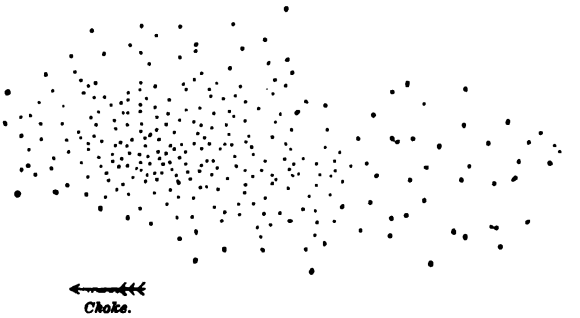
that of personal error; and this demands that the projectile should be spread over an area corresponding at least to one-half of the personal error, magnified by the distance from the actual source of error; and the perfect pattern is one in which the pellets are equally distributed over this area.

With some men a 30-inch circle at 40 yards will cover all personal and other errors; others require a circle of 40 inches, and so on; and happy is the gunmaker who does not know among his customers the man who requires an area the size of the proverbial haystack to cover his error, and to ensure good shooting. From the economic side also a distribution of small pellets is desirable, that the game when killed may be in a state for the table.

The pattern produced is the result of two sets of influences, those within the gunbarrel and those without; and these combined give to the diverging mass of shot a more or less oval or cone shape. The charge of shot attains its highest velocity just inside the gunbarrel; and according to the boring of the gun and other circumstances it begins on leaving the barrel to separate, each pellet taking a distinct line, more or less diverging at an angle from the muzzle.

The line of angle of the pellets is fairly constant, and, as was shown in the *Field* of Nov. 17, 1888, a straight line drawn through the outer pellets of shot gives for easy remembrance the rule that from a choke gun 86 per cent. of the whole charge is included within a circle which is in inches of diameter of equal figure to the yards from the muzzle. That is, with a choke gun at 20 yards from the muzzle, 86 per cent. of the pellets is found within a circle of 20 inches in diameter; at 40 yards, within a 40-inch circle; and so on. With a cylinder gun 60 per cent. of the shot is included in the same comparative measurements. About one yard from the muzzle this divergence begins to show, more or less as the barrel is less or more choked. At two yards this is more evident still, and each succeeding yard shows the difference more and more distinctly. At 10 yards the pattern is distinctly open, and one can begin to form some opinion of its ultimate appearance. [See articles reprinted at pp. 61 to 64 of this book.]

The action of the resistance of the air, and a certain amount of cannoning of the pellets themselves result in producing some such form to the flight of the shot as is here shown, first at 30 yards



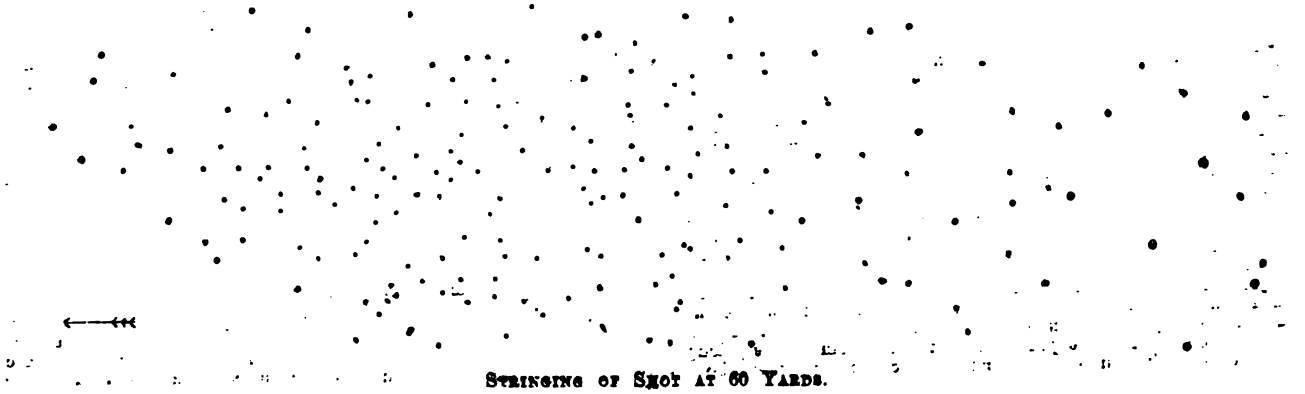
STRINGING OF SHOT AT 30 YARDS WITH CHOKE BORE.

from the muzzle, and then, as shown at the bottom of this page, tailing out still further at 60 yards. The lagging behind of some pellets results in the so-called "stringing" of the shot, which has within limits certain advantages, but it is a difficult matter to study.

In the *Field* I published some attempts I made [see *ante*, pp. 52 to 56] to show the actual state of affairs, and I hope in the near future photography will enable us to know much more about this interesting subject.

Ideal conditions would give a circular pattern with the pellets equally distributed over the area—not necessarily, however, in my opinion, of simultaneous arrival. Such pattern would give, as by a table overleaf, copied from the *Field* of 1888, with a pattern of 220 at 40 yards, three square inches or four circular inches to each pellet on a 30-inch plate; while a pattern of 180 would give five circular inches, and a pattern of 130 seven circular inches. An excellent table of comparative patterns for ready reckoning also appeared in the *Field* of Jan. 18, 1890 (here reprinted at page 253.)

Theoretically, also, the wad between powder and shot should be a perfect plug, permitting no powder gas to get past or through it among the shot pellets. Theoretically, also, the pellets should lie in the cartridge case in regular layers, and should be subjected to no influence likely to break up this regular system.



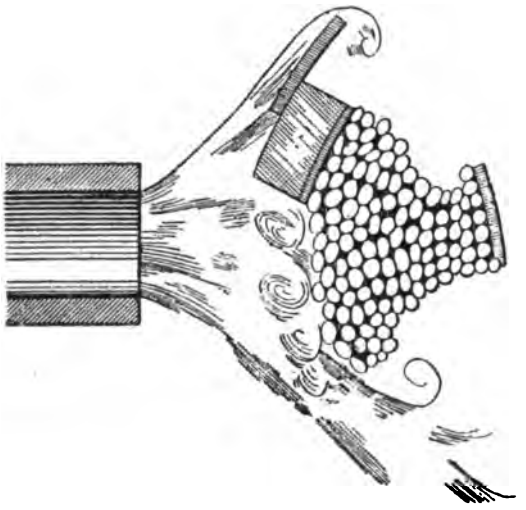
STRINGING OF SHOT AT 60 YARDS.

TABLES OF PELLETS and Area of Pellets in circle of 30in. and Belt from 30in. to 40in. diam. From the *Field*, Nov. 17, 1888.

Range yards.	Thirty-Inch Circle.				Belt from 30in. to 40in. diam.			
	Choke.		Cylinder.		Choke.		Cylinder.	
	Pellets.	Area sq. inch.	Pellets.	Area sq. inch.	Pellets.	Area sq. inch.	Pellets.	Area sq. inch.
20	all	2·3	255	2·8	—	—	29	19·0
25	285	2·5	184	3·5	19	29·0	60	9·2
30	265	2·7	140	5·0	27	20·4	89	6·2
35	257	2·8	130	5·4	33	16·7	65	8·4
40	218	3·2	117	6·0	30	18·3	52	10·6
45	140	5·5	84	8·4	63	8·7	41	13·4
50	115	6·2	78	9·1	54	10·2	38	14·4
55	93	7·6	65	10·9	37	14·9	31	17·7
60	80	8·8	56	12·6	40	13·8	36	15·3

Charge throughout 42 grains Schultze, 1⅛oz. No. 6 shot.

I shall, among my own slides, show some copies of drawings from a translation which appeared in the *Field* in 1892 [here reprinted in subsequent pages], of an article on the shot gun by Capt. Journée, which was published in the "Mémorial des Poudres et Saltpétres," 4th vol., Paris, 1891. These drawings illustrate what is supposed, theoretically, to take place in the gun under different circumstances. And though no one can state positively as yet what actually does take place at the moment of explosion, we do know sufficient to say these theories must be very near the truth.



I need hardly say that an ideal pattern never occurs; many things militate against it, some of which I wish to enlarge upon presently. The result is irregular movement in the barrel, and deformation of the shot pellets; which is the most fruitful source of bad patterns, as the deformed pellets take a more divergent or irregular path than the perfect pellets. If a charge of shot is fired against a soft substance, such as a plate of a low-melting paraffin wax, and the pellets are carefully extracted afterwards, it is found that the exterior contains many more deformed pellets than the interior portion of the pattern.

This deformation is less with chilled shot than with soft shot; and less in cylinder than in choke guns, although the divergence of the cylinder is the greater. Another method of gauging the same effect is by collecting and weighing the actual amount of lead dust produced when a charge is fired. By this I mean the tiny fragments and actual dust produced by the friction of the shot down the gun barrel. It can be estimated by firing the gun upwards at the bottom of a very long large vertical tube; in practice I find it is necessary to use one about 60 feet long, by 4 feet diameter. Hard shot loses more than does soft shot, in dust; but as it retains its shape better than the soft, the resulting deformation is not quite so marked. With a choke, this dust may amount to as much as 20 grains of lead; with a cylinder to as much as 15 grains, when using a charge of 1⅛oz.

So much for the theoretical aspect of the pattern. I propose now to deal with some actual examples. In attempting this, however, one is confronted by the enormous scope of the inquiry, making the giving of even a single instance of each resulting pattern, produced by the combination of influences, a simple impossibility to-day. Let me touch briefly on some of the more important points involved, and which may affect the resulting pattern:

The Gun.—Its calibre. Weight. Length of barrel. Nature of cone. Method of boring. Internal condition.

The Cartridge Case.—Its internal and external diameter. Length. Stiffness of tube. Material of tube. Strength and composition of primer.

The Powder.—Whether black or nitro-compound. Bulky or condensed. Weight of charge. Size of grain. Rate of combustion. Violent or slow. Strong or weak.

The Wadding.—Soft or hard. Tight or loose. Many wads or few. Elasticity. Over-shot wad tight or loose. Thin or thick. Tough or brittle.

The Shot.—Its size. Its lie in the case. Quantity used. Whether soft, hard, or chilled.

The Turnover.—Square or round. Heavy or light.

The Range.—Atmospheric conditions.

It will be seen at once that a complete series of patterns showing the results with all these combinations is absolutely out of my power. We have, say, six principal points, each divided into six minor points, and each of these into at least six other points. To get any information at all reliable, a series of shots must be fired on each point under each circumstance, and at all ranges and under all conditions mentioned. I have made a rough calculation, and think one might hope to get through and give a fair report on a series of about eighteen thousand millions. Your patience would not last, if my energy did, in attempting to give you an example of each. So I will, from my former experiences, pass over very rapidly the greater number, and bring down the actual examples to about twenty loads, fired from guns with three systems of boring, with three kinds of shot, making the series of about a thousand shots, to which I have already referred.

But if anyone is ambitious of carrying out a complete series of tests for patterns, I would suggest the following as a fairly complete scheme for the purpose. Let him try guns of five calibres, of three different weights, with three lengths of barrel, and two kinds of cone, with three methods of boring; and let him use three kinds of cartridge case, with three strengths of cap, loading with, say, six kinds of powder, with three charges, and powders to show four different qualities as to strength and rate of combustion. The wadding to be of about eight different kinds between powder and shot, and of three kinds over shot; the shot to be of three kinds, and of five different sizes, adapted to lie in the case or not. Let the turnover be of four kinds; and shoot the whole at six different ranges.

To take a single shot under each of these complications will involve a series of more than three thousand millions of rounds; and as at least six shots are required for a test, let us say in round numbers eighteen thousand millions. And let him hurry up, or the rush of new powders will so involve him in new tests, that he will end off in fifty years with more to do than when he started!

But, before passing on, I must say a word on the big figure I have just mentioned. If you carefully estimate the causes we already know which may affect the resulting pattern, and take the law of chances or averages, you will find this figure of eighteen thousand millions is within the actual calculation against there being a second pattern exactly like the first. You must not expect to repeat the exact conditions of one pattern in less than fifteen to twenty thousand million times. So that, had I seen the pattern which has been produced by every cartridge that has been fired from a shot gun in this country in my lifetime, I should not yet have arrived, nor can I hope to arrive, at the second pattern produced under the exact conditions with the first.

Now as to my small manageable group:—

1. *Calibre of Gun.*—The rule holds fairly well with all calibres, that the smaller the calibre the less is it affected by tightness or looseness of the wad, condition of the turnover, or the nature of the over-shot wad. Also, slight variations in the actual internal diameter

from the nominal bores do not affect the pattern, provided the wads are equally tight fitting; although velocity is increased with a nitro when the bore is smaller rather than larger than its actual nominal size. I shall therefore confine my remarks to results with a nominal 12-bore gun.

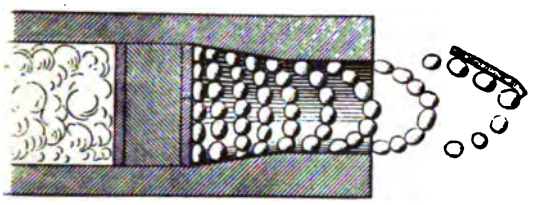
2. *Weight of Gun.*—The heavy gun, as a rule, gives more regular patterns than does the very light gun. This is frequently traceable to the large amount of metal left at the actual muzzle, which, by resisting expansion, acts somewhat after the manner of the choke; but, independently of this, the rule as to heavy and light guns I find fairly constant. I shall report, therefore, on guns between 6½lb. and 7½lb.

3. *Length of Barrel.*—This was examined exhaustively in the *Field* in August, 1888. [See *ante*, pp. 170 to 172.] There is little effect on the pattern until the length is reduced below 26in. I prefer myself 28in. barrels for Schultze powder. I shall show results, therefore, only with the barrels 28in. to 30in. long.

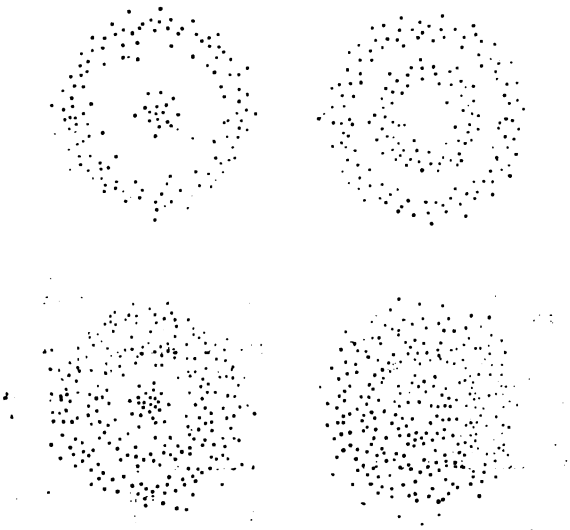
4. *Cone of Chamber.*—Deformation of the shot is more with a square than with a taper cone. I shall refer to a taper cone only.

5. *Boring of the Barrel.*—This has such an effect on the pattern, that I shall show comparison of eight different kinds of boring, but follow out the series with three kinds only—Choke, Nominal Cylinder, True Cylinder.

I show here a view indicating the probable action of choking in keeping the area of the spread smaller. The shot pellets are thrown over on themselves.



An extremely vital essential is that the boring must be free from any rifling or spiral groove which would tend to throw the charge of shot into a revolving condition. The result of such in the pattern is the production of what we may call cart-wheel patterns, examples of which are shown in the four patterns here reproduced.



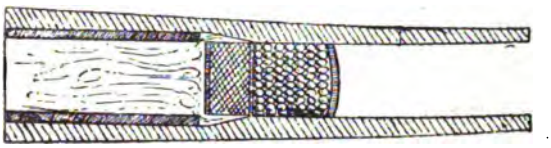
CART-WHEEL PATTERNS.

6. *The Cartridge Case.*—The more true this is to its gauge, both in internal and external measurements, the better is the effect on the regularity of the pattern. I show results only with well-fitting cases.

7. *The Length of the Cartridge Case.*—This is hardly material if it of such a length as to correspond with the chamber of the gun. Otherwise it has a very important influence. I shall show patterns with the chamber correct, also too long and too short for the cartridge case.

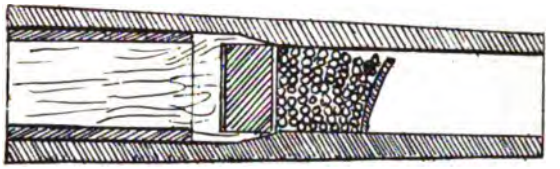
To illustrate this I have a view showing the action when the chamber is (*a*) of correct length for the case.

(*a*)



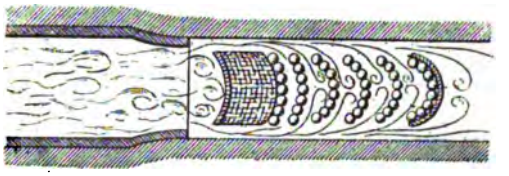
Also one (*b*) showing the chamber too long for the case. In this instance the gases get past the wad, and will assuredly spoil the pattern, probably producing clustering also.

(*b*)



Also (*c*) showing where the case is too long for the chamber. In this instance the shot is jammed, and balling will be the result.

(*c*)



8. *The Nature of the Tube.*—This has a considerable effect when nitros are used, though not so much with black powder. It is, however, readily adjusted by means of proper wads and turnover. I shall refer to one kind only, the stiff paper tube.

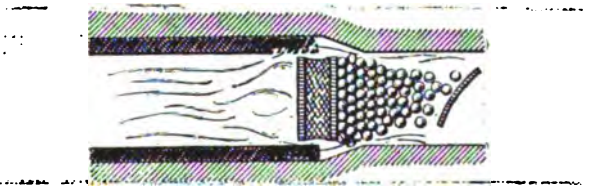
9. *The Primer.*—The strength and composition of this has but little influence on the patterns within ordinary limits; beyond these it does have some effect. I shall therefore refer to three strengths—normal, strong, and extra strong caps.

10. *The Powder.*—Nitros with equal velocity can give a better pattern than black. I shall not refer to this, therefore. And for the nitros, there are now so many different kinds that I hope I may be excused if I confine myself to that which I understand the best, my own powder, Schultze.

11. *The Charge of Powder.*—Within certain limits it has not much effect on the pattern; beyond this it has some effect. I shall show examples of three different charges.

12. *Rate of Combustion of the Powder.*—This has considerable effect on the pattern. I shall show results with three different rates of combustion.

13. *The Wadding. Whether Tight or Loose.*—Now a tight wad is an absolute essential to good patterns. I show a view illustrating a loose wad and the powder gas passing—a fruitful source of balling. I shall show the results with each kind.



14.—*Wads. Soft or hard. Thick or thin.*—These all affect the pattern. I shall show results with each variation.

15. *Wads. Many or Few.*—This is also a material point; but as a fair amount between powder and shot is necessary, I shall show with this only—that is, from ½ to ⅝ inch in all.

16. *Wads. How Placed.*—That is, squarely or slanting. It is essential that the wads rest squarely in the case. I shall show results with both positions of the wad.

17. *The Shot.*—The size affects the pattern; the smaller the shot, the more irregular the pattern, other things being equal. I shall confine my results to one size only, that is No. 6, running 270 to the ounce.

18. *Charge of Shot.*—This does affect the pattern naturally; but as any increase in the shot charge is generally accompanied with a corresponding increase in the powder charge, and this controls the resulting pattern, I shall show results with one charge only, that is 1⅛ ounce.

19. *Nature of the Shot. Whether Soft, Hard, or Chilled.*—The softer the shot the more there is a risk of deformation and irregular pellets. I have used all three kinds very extensively, and will now show a comparative table of results with each kind, on a long series of shots.

There is a little variation in the specific gravity of the shot I used, but all the patterns were taken with the same number of pellets, 304. I find the soft shot gives only 299 pellets, and the hard shot only 297 pellets to the 1⅛ ounce; while the chilled weighs exactly this amount with the 304 pellets. The patterns shown will be with chilled shot.

COMPARISON OF PATTERNS taken with 42 grs. Schultze and 1¼oz. (304 pellets) No. 6 Soft, Hardened, and Chilled Shot. Range 40 yards. Average of 100 shots each kind.

Gun Target.	Choked ·740" to ·706".			Nom. Cylinder ·740" to ·717".			True Cylinder ·734".		
	30".	6ft.	Total.	30".	6ft.	Total.	30".	6ft.	Total.
Soft Shot	206	83	289	155	117	272	118	149	267
Difference on lowest ...	25%	—	5%	28%	—	21%	36%	—	22%
Hardened Shot	208	82	290	158	118	276	121	146	267
Difference on lowes ...	22%	—	5%	29%	—	20%	34%	—	22%
Chilled Shot	211	82	293	157	122	279	121	149	270
Difference on lowes ...	20%	—	4%	27%	—	20%	33%	—	22%

20. *The Turnover.*—This has a great influence on the pattern, and varies according as a light, normal, or heavy turnover is given to the case—the usual rule being, the heavier the turnover, the lighter the pattern; but this does not always hold good. I shall show examples of patterns with each; that is, with the turnover of about one-eighth, one-fourth, and three-eighths of an inch respectively.

COMPARISON OF RESULTS obtained with various degrees of Choking of the Barrel, averages of many rounds with 42 grains Schultze, and 1¼oz. No. 6 shot, Soft, Hardened, and Chilled:

Length of Barrel.	Amount of Choke.	Mean Velocity.		Pattern, 40 yards.		
		Muzzle.	40 yds.	30"	6 ft. ring.	Total, 6 ft. diam.
		ft.sec.	ft.sec.			
30"	·740" to ·704"	1235	876	232	80	302
30"	·735" ,, ·705"	1233	875	218	82	300
28"	·738" ,, ·705"	1233	872	217	81	298
28"	·740" ,, ·706"	1229	870	212	83	295
30"	·740" ,, ·707"	1224	868	209	80	289
28"	·735" ,, ·713"	1219	860	183	103	286
28"	·740" ,, ·717"	1195	844	155	121	276
30"	·734" ,, ·734" none.	1158	818	120	152	272

The enormous mass of varieties is now reduced for our present purposes to experiments made with 12-bore central fire double-barrel guns, from 6½lb. to 7½lb. in weight, 28in. to 30in. long in the barrel, with taper cone. The cases well fitting, true to dimensions, stiff paper tubes, loaded with Schultze powder, with a fair amount of wadding between powder and shot, and 1¼oz. No. 6 chilled shot. The gun fired from the shoulder.

With this as a foundation, I have tried eight different kinds of boring for comparison in pattern and velocity, and from these I have selected three guns for the pattern experiments. The foregoing table shows the results with the eight systems of boring, and it will be seen that the pattern and the velocity run higher in regular sequence with the amount of choking in the gun.

Enquiries on patterns may run on two distinct lines—either in an attempt to improve the pattern of a poor shooting gun, or to show the variations possible even with a really good shooting gun. I did think at one time of taking up the first method for to-day, and it is very interesting to watch the improvement step by step; but the time at my disposal is too short, and also nowadays the boring of the gun is carried to such a pitch of excellence that it is somewhat difficult to find a selection of bad guns. So I shall confine myself to the other path, that of showing how with a very good shooting gun the pattern may be increased or spoiled by various conditions of the load. Among these conditions the wadding has the most important place on the whole; my first eight patterns will therefore form a group on differences of the wadding. Then I will follow with groups as to turnover, length of chamber, strength of caps, charge of powder, and strength of powder.

And now let me explain the patterns that will be shown to you. First will be thrown upon the screen the table of the actual conditions of the gun, load, case, &c., and then will follow a pattern produced under such conditions. For each of the patterns shown, about ten shots were fired with three different kinds of barrel, that is—

A choke measuring ·740 to ·707 of an inch.
A nominal cylinder measuring ·740 to ·717 of an inch.
A true cylinder measuring ·734 of an inch.

The pattern I have selected for each plate is the one which, on examination of the series, appeared to show the pattern characteristic the best. You may take each to be, therefore, a sample of the average pattern produced under such circumstances in any series that may be fired. I found the distinctive features of the pattern run fairly true, whether it be choke or cylinder; and as, from the open nature of the cylinder pattern, the differences are not so accentuated, I shall show, with a few exceptions, patterns from a choke only. Moreover, I find such choke patterns, reduced to the proportionate number, fairly represent the cylinder pattern with the same load. But, for information, I will put alongside the choke results those also obtained with the more open bores. Also, I will show the lowest shot in the series, and the percentage difference between this and the average, as this gives us valuable information on the score of regularity. The plates will show the pellets in the 30-inch circle, and also those in a ring outside of this up to 6 feet in diameter.

The range in every case 40 yards.

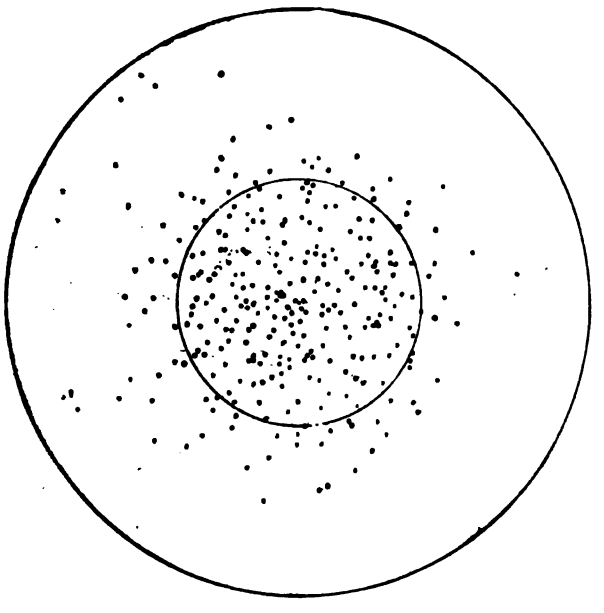
FIRST GROUP.—WADDING.

No. 1.—Shows the ordinary "Field" system of loading—a very excellent one, depending for its usefulness on the tight powder wad. A choke pattern is reproduced.

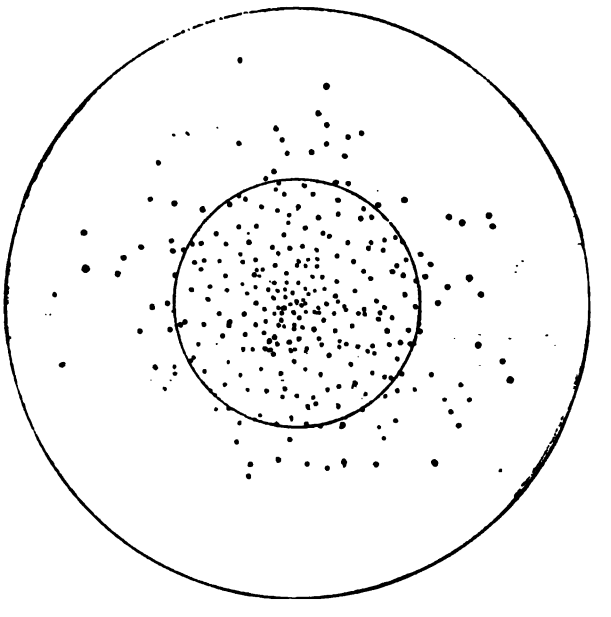
Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder "Field" Wad, 11¾ gauge (old orm).
do. Felt, ½in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1¼oz., No. Chilled (304 pellets).
Turnover, Fair.
Internal Pressure, 1in., 2·69 tons.
Internal Pressure, 2½in., 3·71 tons
Gun Recoil, 25·2.
Time in Barrel, ·0051 sec.
Muzzle Velocity, 1206ft.

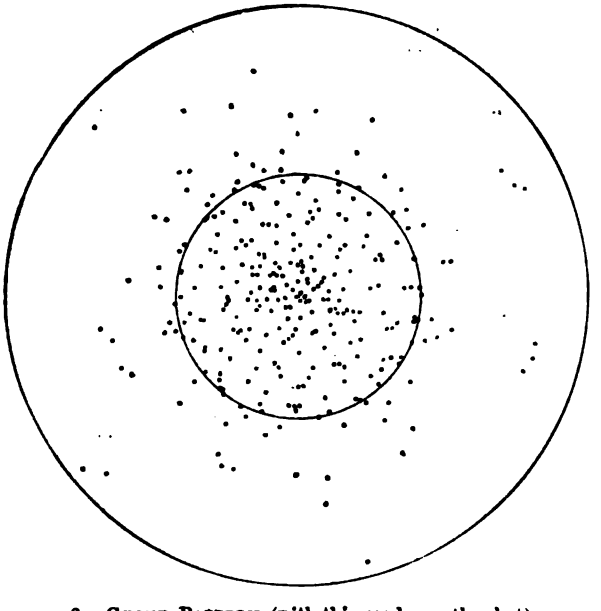
	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	201	151	114
Do. 6ft.	94	134	150
Total	295	285	264
Lowest Difference %, 30in. ...	14	24	18
Do. Do. 6ft. ...	6	11	11
Total	288	258	286



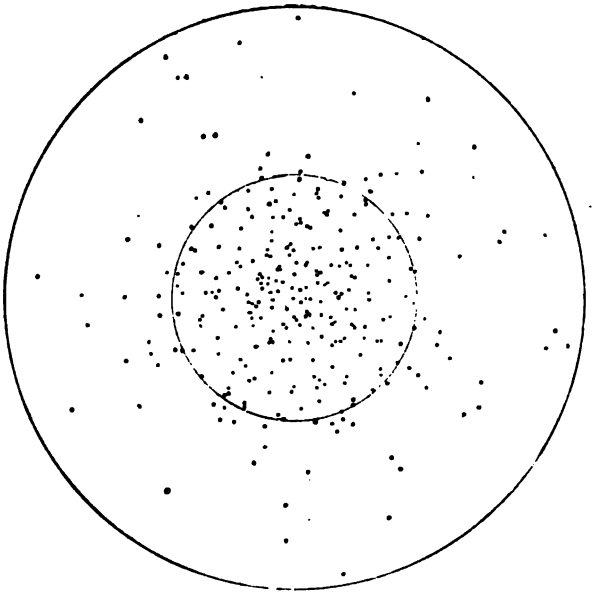
1.—Choke Pattern (with thick "Field" wad).
30in., 201. 6ft., 94. Total 295.



2.—Choke Pattern (with thinner "Field" card).
30in., 215. 6ft., 85. Total 300.



3.—Choke Pattern (with thin card over the shot).
30in., 218. 6ft., 78. Total 296.



4.—Choke Pattern (with very soft felt wad).
30in., 210. 6ft., 84. Total 294.

No. 2.—The difference between this system and the preceding one is in the substitution of a "Field" *card* for the older and thicker form. I have come to the definite conclusion that with the stronger caps of the present day, this form of wad is even better for the powder than the thicker "Field" wad, giving as it does a little more regularity and velocity than the former. A choke pattern is reproduced (see previous page).

Length of Case, 2½in.
Primer Strength, 100units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅜in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·71 tons.
Internal Pressure, 2½in., 2·77 tons.
Gun Recoil, 26·0.
Time in Barrel, ·0056sec.
Muzzle Velocity, 1230ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	215	159	122
do. 6ft.	85	126	150
Total	300	285	272
Lowest Difference %, 30in. ...	18	20	20
do. do. 6ft. ...	4	11	8
Total	288	255	249

No. 3.—The difference between this system and the preceding one is the use of a thin card wad over the shot, instead of a thick one. It frequently gives a little better pattern than the thicker wad, with a little loss on velocity. But it has a tendency at the same time to distribute the pellets in lines. A choke pattern is reproduced.

Length of Case, 2½in.
Primer Strength, 100 uni
Powder Charge, 42grs.
Wads, on Powder, "Field' Card, 11¾ gauge.
do. Felt, ⅜in.
do. Card, Thin.
do. Thin Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover. Fair.
Internal Pressure, 1in., 2·65 tons.
Internal Pressure, 2½in., 2·67 tons.
Gun Recoil, 26·0
Time in Barrel, ·0063 sec.
Muzzle Velocity, 1222ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	218	165	121
do. 6ft	78	106	152
Total	296	271	273
Lowest Difference %, 30in. ...	14	35	45
do. do. 6ft. ..		15	17
Total	282	229	225

No. 4.—In this loading a very soft felt wad is used, instead of the ordinary firm one, in conjunction with a thin card for the over-shot wad. It is useful in a gun that is worn or large for the bore, and also when a gun has a tendency to form clusters with a harder wad. Otherwise it has very little effect.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt. Very Soft, ⅜in.
do. Card. Thin.
do. Thin Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·49 tons.
Internal Pressure, 2½in., 2·57 tons.
Gun Recoil, 24·8.
Time in Barrel, ·0066sec.
Muzzle Velocity, 1215ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	210	146	120
Do. 6ft.	84	128	147
Total	294	274	267
Lowest Difference % 30 ..	18	44	55
Do. Do. 6ft. ...	5	9	16
Total	290	249	225

No. 5.—This, on the contrary, is with very hard wads. Hard wads always increase the velocity, and also very much the pressure; in fact, it is possible to get equal penetration with a less charge of powder when very hard wads are used. But this pattern is nearly always spoiled by such wads running patchy and sometimes balling.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, 4 Hard Black Edge. Tight Fitting.
do. Felt, none.
do. Card, none.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 3·77 tons.
Internal Pressure, 2½in., 3·95 tons.
Gun Recoil, 30·6.
Time in Barrel, ·0048sec.
Muzzle Velocity, 1294ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	207	163	108
do. 6ft.	79	106	149
Total	286	269	257
Lowest Difference %, 30in. ...	38	44	36
do. do. 6ft. ...	6	9	6
Total	298	244	242

No. 6.—This is loaded with loose wadding all through—wads that drop into the case. It is entirely *fatal* to good shooting; the powder gases get past the wads into the shot, and the pattern is not only spoiled, but the penetration injured very considerably. It is a fruitful source of balling.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, Card.
do. Felt, ⅜in.
do. Thin Card.
do. Thick Card over Shot.
(Wads all loose.)

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·18 tons.
Internal Pressure, 2½in., 2·46 tons.
Gun Recoil, 20·1.
Time in Barrel, ·0060 sec.
Muzzle velocity, 926ft.

	Choke.	Nominal. Cylinder.	True. Cylinder.
Pattern, 30in.	108	106	96
do. 6ft.	142	132	133
Total	250	238	228
Lowest Difference %, 30in. ...	18	25	28
do. do. 6ft. ...	6	11	10
Total	236	212	206

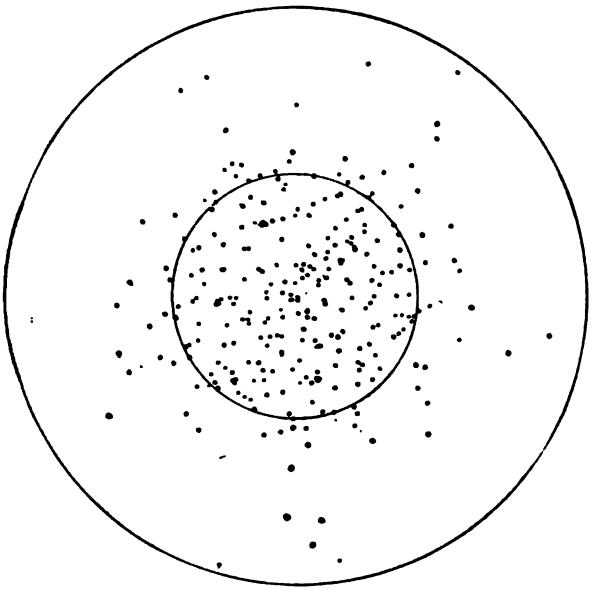
No. 7.—In this case the powder wad was pushed down slanting, and left so. When this happens, it always means a loss of velocity, and the pattern is damaged more or less, very often being thrown over on the side to which the slanting wad pointed.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾. (slanting).
do. Felt, ⅜in.
do. Card. Thin Card.
do. Thick Card over Shot.

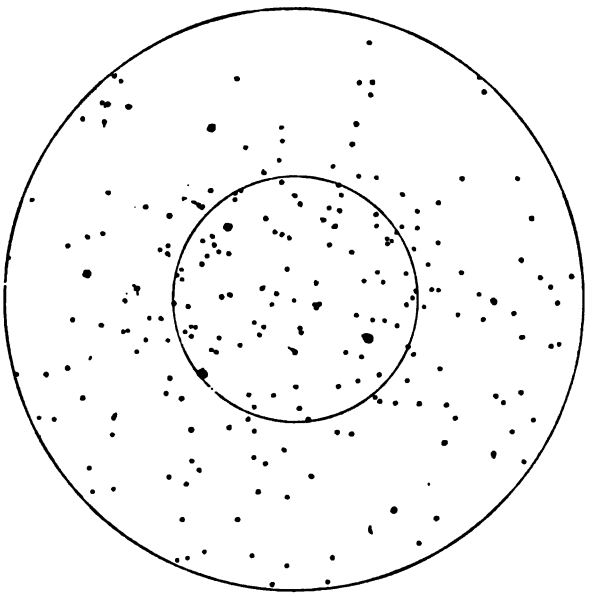
Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·70 tons.
Internal Pressure, 2½in., 2·80 tons.
Gun Recoil, 26·2.
Time in Barrel, ·0556sec.
Muzzle Velocity, 1188ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	197	150	119
Do. 6ft.	92	118	146
Tota	289	268	265
Lowest Difference %, 30in. ...	17	2	25
Do. Do. 6ft. ...		7	3
Total	282	249	246

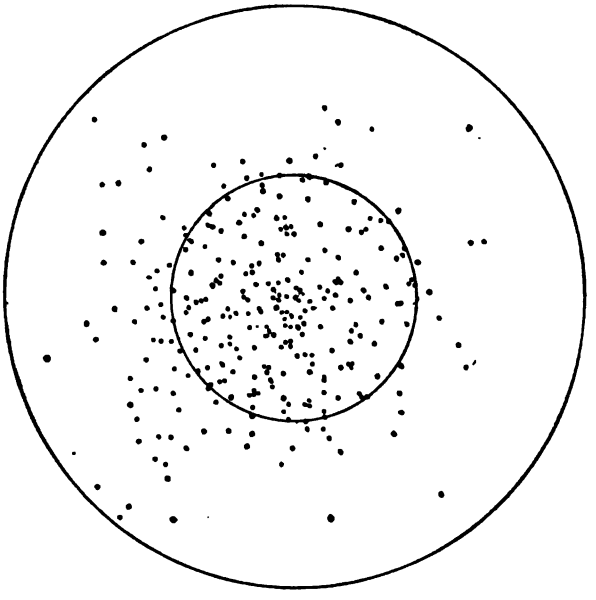
No. 8.—Here all the wads were pushed in slanting, and the turnover was also oblique; it is an exaggerated example, but one sees something approaching it sometimes. The result is a still further



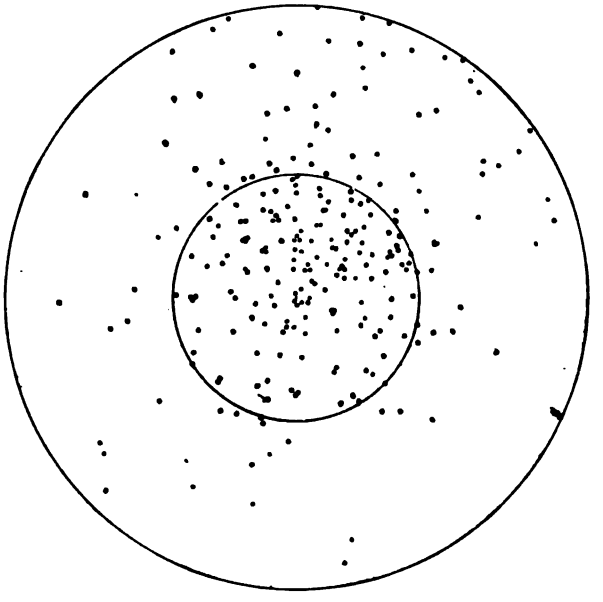
5.—Choke Pattern (with very tight-fitting hard wads).
30in., 207. 6ft., 79. Total 286.



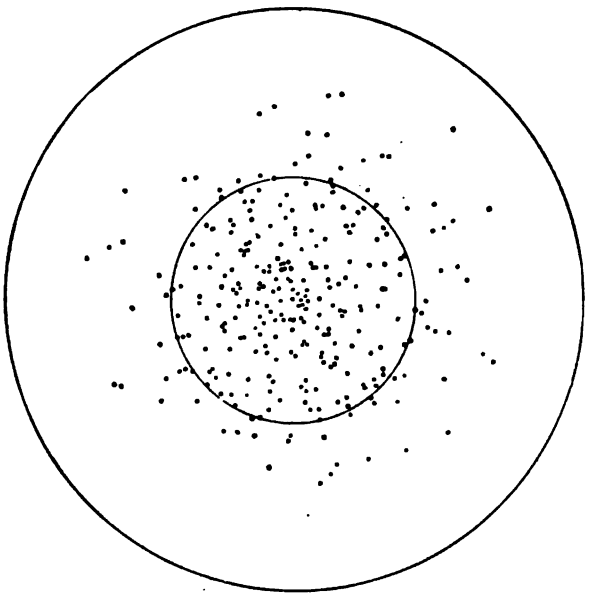
6.—Choke Pattern (with very loose wads).
30in., 106. 6ft., 142. Total 250.



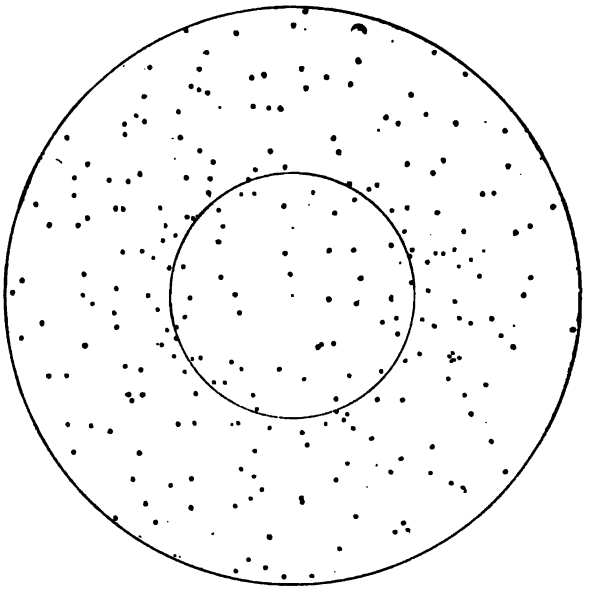
7.—Choke Pattern (with one slanting wad).
30in., 197. 6ft., 92. Total 289.



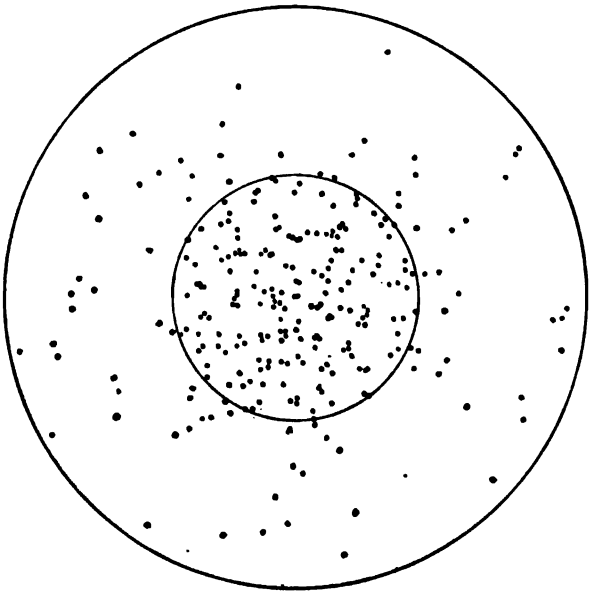
8.—Choke Pattern (with all wads slanting).
30in., 160. 6ft., 95. Total 255.



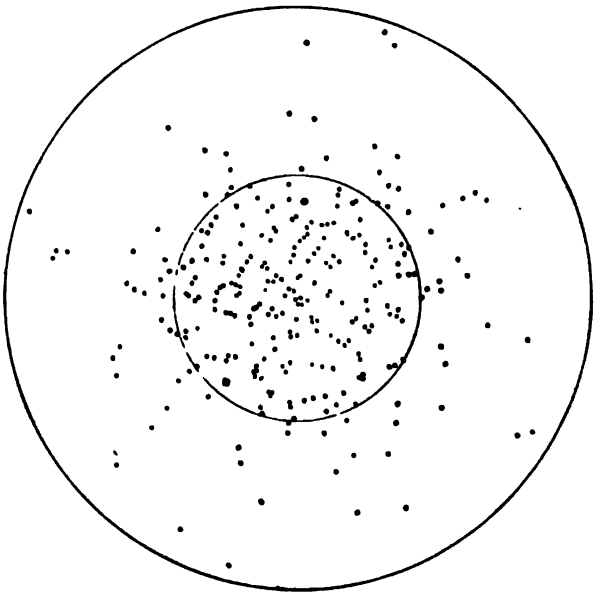
9.—Choke Pattern (with light turnover).
30in., 210. 6ft., 79. Total 289.



9A.—True Cylinder Pattern (with light turnover).
30in., 45. 6ft., 200. Total 245.



10.—Choke Pattern (with very heavy turnover).
30in., 192. 6ft., 80. Total 272.



11.—Choke Pattern (with long cartridge case).
30in., 194. 6ft., 82. Total 276.

loss of velocity, and a pattern thrown distinctly over towards the way of the slant; in this case it was pointing upwards.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.
(All the wads slanting.)

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·76 tons.
do. do. 2⅜in., 2·72 tons.
Gun Recoil, 25·5.
Time in Barrel, ·0060sec.
Muzzle Velocity, 1115ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30ins.	160	121	90
do. 6ft.	95	127	144
Total	255	248	234
Lowest Difference %, 30in. ...	54	25	45
do. do. 6ft. ...	8	8	12
Total	234	227	206

SECOND GROUP.—TURNOVER.

No. 9.—This case was turned over only about ⅛in. It always means loss of velocity, and generally an increase in the pattern, but a tendency to a patchy pattern. With a cylinder sometimes one gets a cart-wheel pattern with this light turnover. Patterns with a choke and a cylinder gun are reproduced.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Very Light.
Internal Pressure, 1in., 2·13 tons.
Internal Pressure, 2⅜in., 2·18 tons.
Gun Recoil, 25·0.
Time in Barrel, ·0067 sec.
Muzzle Velocity, 1196ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	210	156	123
do. 6ft.	79	115	137
Total	289	271	260
Lowest Difference %, 30in. ...	25	38	51
do. do. 6ft. ...	4	3	6
Total	276	262	245

No. 10.—In the next a very heavy turnover was used, about ⅜in. This always increases the pressures, but with no corresponding increase in velocity; and it nearly always spoils the pattern, making it patchy, and inclined to cluster.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Very Heavy.
Internal Pressure, 1in., 3·03 tons.
Internal Pressure, 2⅜in., 3·09 tons.
Gun Recoil, 26·6.
Time in Barrel, ·0054sec.
Muzzle Velocity, 1205ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	192	141	118
do. 6ft.	80	125	135
Total	272	266	253
Lowest Difference %, 30in. ...	29	42	24
do. do. 6ft. ...	7	14	11
Total	254	229	226

THIRD GROUP.—LENGTH OF CHAMBER.

No. 11.—In this case a 2⅜in. case was used in a 2½in. chamber. This will increase the pressures and generally the velocity, but gives patchy patterns, clustering, and frequently balling. Sometimes a fine specimen of a cart-wheel pattern results when such conditions arise in a cylinder gun. A cylinder pattern is also shown (on the following page).

Length of Case, 2⅜in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 3·22 tons.
Internal Pressure, 2⅜in., 3·27 tons.
Gun Recoil, 28·7.
Time in Barrel, ·0052sec.
Muzzle Velocity, 1237ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	194	153	116
do. 6ft.	82	120	146
Total	276	276	262
Lowest Difference %, 30in. ...	15	14	42
do. do. 6ft. ...	0	9	16
Total	276	248	221

No. 12.—Here the conditions are still worse, for the case was 3in. long, in a 2½in. chamber. Such a condition will not often arise, but it does sometimes. The result is an enormous strain on the gun, a large velocity, and always more or less balling (see next page).

Length of Case, 3in.
Primer Strength, 100 units.
Powder Charge, 42 grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in. by ⅛in.
do. Card, Thin Card.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 3·71 tons.
Internal Pressure, 2⅜in., 3·52 tons.
Gun Recoil, 30·2.
Time in Barrel, ·0048sec.
Muzzle Velocity, 1261ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	178	134	103
do. 6ft.	95	120	145
Total	273	254	248
Lowest Difference %, 30in. ...	45	24	23
do. do. 6ft. ...	7	5	4
Total	254	241	237

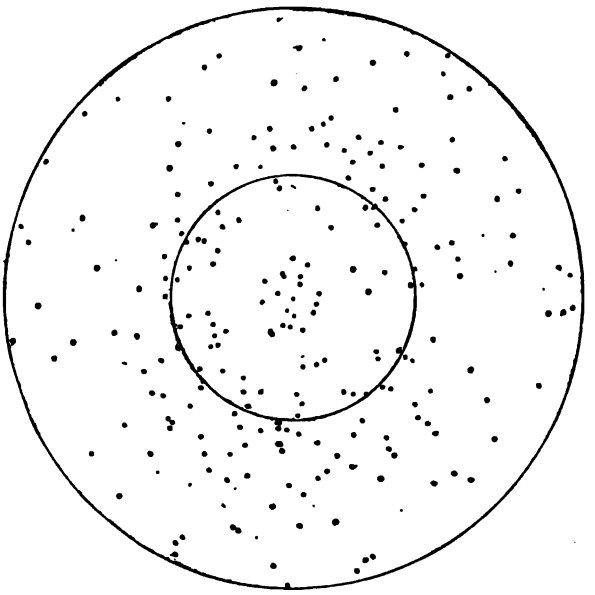
FOURTH GROUP.—STRENGTH OF CAP.

No. 13.—This cap is of the strength as called by Messrs. Eley their medium cap, and is about the same as issued by other makers. An increase in strength of this nature has no effect on the pattern at all. It quickens the time of ignition a little, however; and, as a cap of this strength is less likely to show the effect of insufficiency of fulminate from irregular loading, I am now recommending such caps for our powder. The velocity is generally improved a few feet.

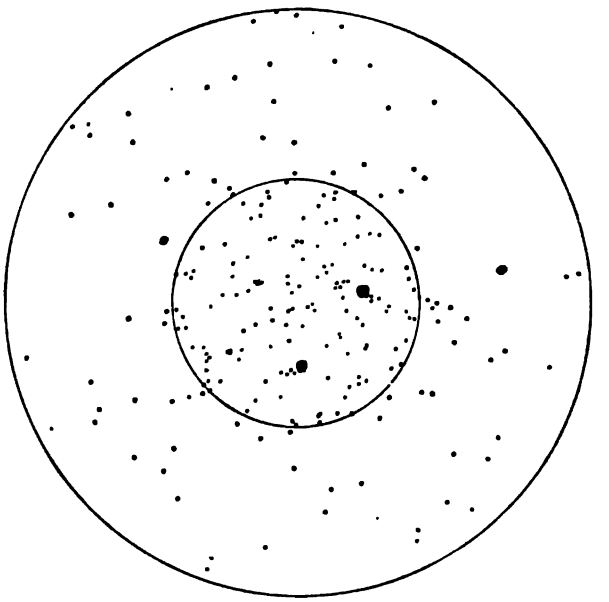
Length of Case, 2½in.
Primer Strength, 150 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in. Felt.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·75.
Internal Pressure, 2⅜in., 2·81.
Gun Recoil, 25·9.
Time in Barrel, ·0046sec.
Muzzle Velocity, 1237ft.

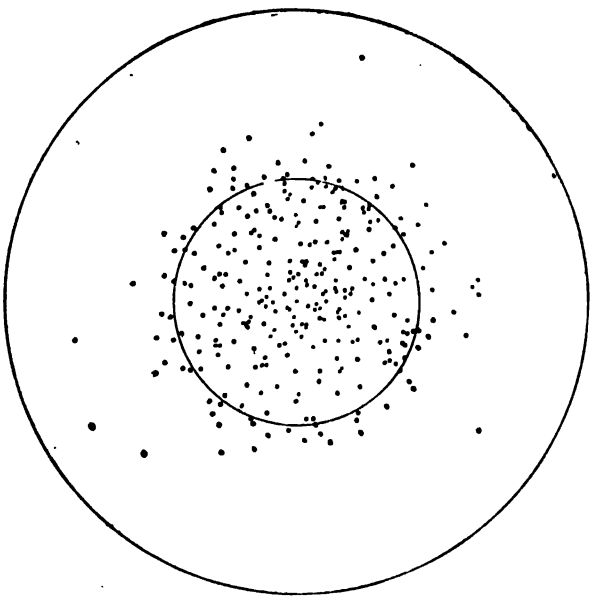
	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	215	161	120
do. 6ft.	83	128	149
Total	298	289	269
Lowest Difference %, 30in. ...	15	23	20
do. do. 6ft. ...	3	15	6
Total	288	246	252



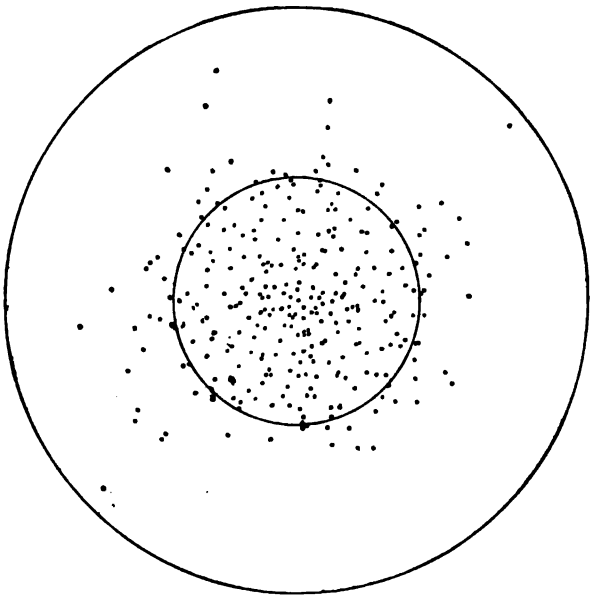
11A.—True Cylinder Pattern (with long cartridge case).
30in., 67. 6ft., 154. Total 221.



12.—Choke Pattern (with long cartridge case).
30in., 178. 6ft., 95. Total 273.



13.—Choke Pattern (with medium cap).
30in., 215. 6ft., 83. Total 298.



14.—Choke Pattern (with strong cap).
30in., 212. 6ft., 80. Total 292.

No. 14.—This is a cap of still greater strength. It has a little effect in reducing the pattern, but very little. It does, however, increase the pressures, and shows no corresponding advantage in velocity.

Length of Case, 2½in.
Primer Strength, 180 units.
Powder Charge, 42grs.
Wads on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 2·82 tons.
Internal Pressure, 2½in., 2·89 tons.
Gun Recoil, 26·3.
Time in Barrel, ·0042sec.
Muzzle Velocity, 1236ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	212	154	118
do. 6ft.	80	122	140
Total	292	276	258
Lowest Difference %, 30in. ...	20	27	20
do. do. 6ft. ...	7	12	4
Total	272	241	248

FIFTH GROUP.—CHARGE OF POWDER.

No. 15.—An increase of ¼ dram of powder gives, of course, a corresponding increase in velocity and pressure, and lowers the pattern, but without spoiling it.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 45½grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 3·23 tons.
Internal Pressure, 2in., 3·29 tons.
Gun Recoil, 29·6.
Time in Barrel, ·0055 sec.
Muzzle Velocity, 1274ft.

	Choke.	Nominal. Cylinder.	True Cylinder.
Pattern, 30in.	192	147	116
do. 6ft.	92	123	148
Total	284	270	264
Lowest Difference %, 30in. ...	17	25	21
do. do. 6ft. ...	2	13	6
Total	278	235	246

No. 16.—An increase to 3½ drams of powder still further increases the velocity and pressures, and it also begins to operate against the pattern, making it poorer and more irregular.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 49grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in. 3·87 tons.
Internal Pressure, 2½in. 3·84 tons.
Gun Recoil, 33·9.
Time in Barrel, ·0069sec.
Muzzle velocity, 1328ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	182	136	111
do. 6ft.	91	117	140
Total	273	253	251
Lowest Difference %, 30in. ...	39	33	33
do. do. 6ft. ...	9	8	4
Total	249	233	242

SIXTH GROUP.—STRENGTH OF POWDER.

No. 17.—The powder here was made specially strong and quick in combustion. Such gives, of course, more pressure and a greater velocity to the shot, but it at the same time spoils the pattern, making it patchy and clustering.

Length of Case, 2½in.
Premier Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.

Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover Fair.
Internal Pressure, 1in., 3·28 tons.
Internal Pressure, 2½in., 3·19 tons.
Gun Recoil, 28·1.
Time in Barrel, ·0048sec.
Muzzle Velocity, 1249ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	181	140	111
do. 6ft.	85	107	135
Total	266	247	246
Lowest Difference %, 30in. ...	78	49	59
do. do. 6ft. ...	14	11	14
Total	228	221	212

No. 18.—This powder was made specially weak. The result is a very poor velocity, and low pressures, but this is not counterbalanced by a very fine pattern, with such the pattern is usually drooping and patchy. With such powder and loose wads, balling can be produced readily.

Length of Case, 2½in.
Primer Strength, 100 units.
Powder Charge, 42grs.
Wads, on Powder, "Field" Card, 11¾ gauge.
do. Felt, ⅛in.
do. Card, Thin.
do. Thick Card over Shot.

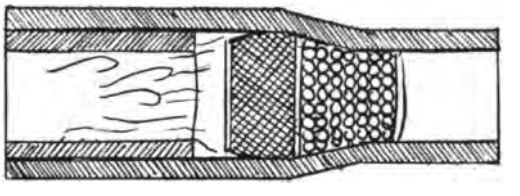
Shot, size and weight, 1⅛oz., No. 6 Chilled.
Turnover, Fair.
Internal Pressure, 1in., 1·83 tons.
Internal Pressure, 2½in., 1·83 tons.
Gun Recoil, 22·6.
Time in Barrel, ·0079sec.
Muzzle Velocity, 1081ft.

	Choke.	Nominal Cylinder.	True Cylinder.
Pattern, 30in.	185	160	128
do. 6ft.	96	121	150
Total	281	281	278
Lowest difference %, 30in. ...	22	70	37
do. do. 6ft. ...	7	11	11
Total	261	250	247

Now a word as to BALLING OR CLUSTERING. This arises from one of two causes.

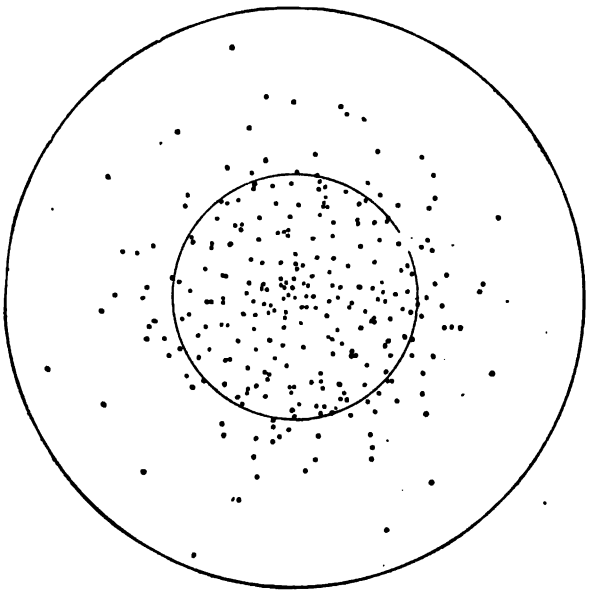
1. By *Welding* of the shot.—This is caused either by violent impact against the wad, or the turnover, or the cone; or from violent powder, or from an over load. When arising from these causes, it may often be cured by using a softer wad, so as to provide a kind of spring to break the blow. It is also caused by using too long a case in the chamber, the shot being jammed together.

2. By *fusion* of the shot itself.—This is caused by the hot gases of the powder combustion getting past the wad and among the pellets of the shot; either from too loose a wad, or from too long a chamber

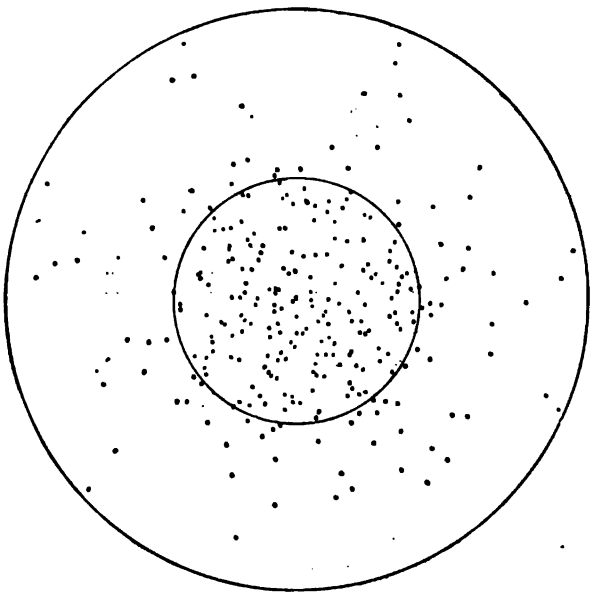


A tighter wad will often cure this in the first case, and a more elastic wad in the other case. The elastic wad swells out, as is shown here, and stops the passage of the gases.

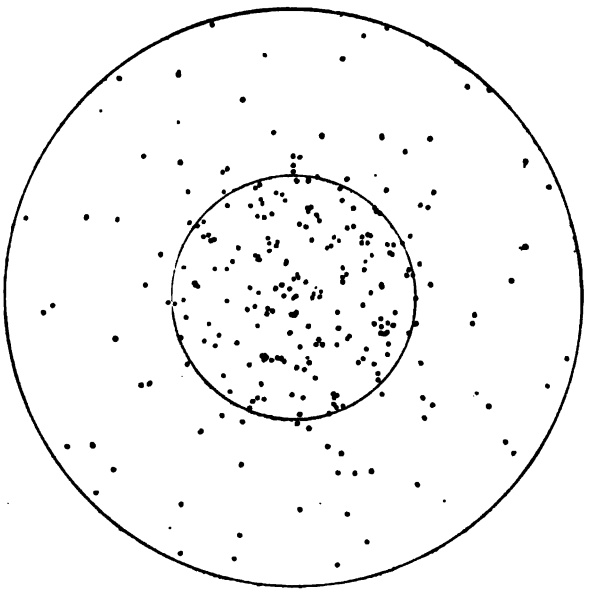
This balling is more found with the cylinder guns than with the chokes—the constriction in the latter breaking up the mass of shot somewhat, and producing clustering rather than balling. I have traced it sometimes to the fact that the actual bore of the cylinder



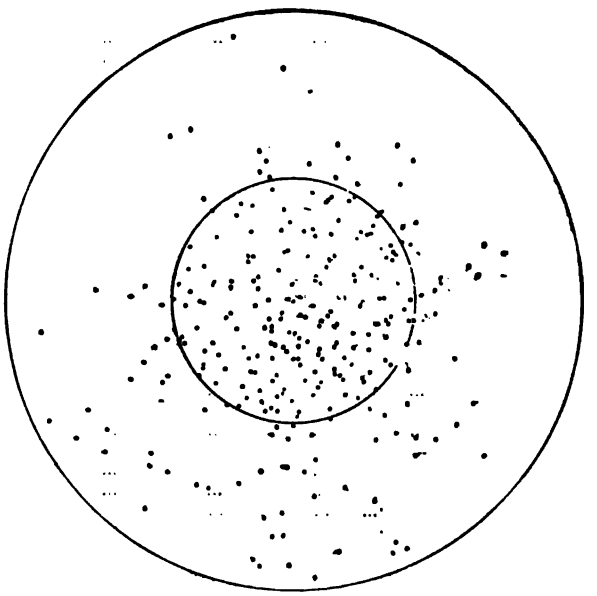
15.—Choke Pattern (with increase of powder).
30in., 192. 6ft., 92. Total, 284.



16.—Choke Pattern (with further increase of powder).
30in., 182. 6ft., 91. Total 273.



17.—Choke Pattern (with specially quick powder).
20in., 181. 6ft., 85. Total 266.



18.—Choke Pattern (with weak powder).
30in. 185. 6ft., 96. Total 281.

barrel is larger than that of the choke, though of the same nominal figure.

It only remains with me now to express a hope I have not utterly wearied you with a very uninteresting subject. I can hardly hope to have brought out any point not already well known to the experts before me; but I shall be glad to have be ped in any way to confirm such knowledge, and to have taken one step nearer towards making the science of the shot gun a certain one.

My grateful acknowledgements are due to my assistants; to Mr. Wadsworth for carrying out the actual loading and shooting of the series, and to Mr. Robertson for making the photographic representations used to illustrate this lecture.

SUMMARY OF SHOT PATTERNS, VELOCITIES, &c.

(*Field*, March 5, 1898; Vol. 91, p. 347.)

The mass of information contained in Mr Griffith's lecture is so great, and the experiments described are so numerous, that it is not easy to take a "bird's-eye view" of the whole, and make a comparison of results. We have therefore thought it desirable to frame a concise summary of the experiments, so as place the statistics in juxtaposition, and thus enable the reader to more readily trace the connection between cause and effect. We think this summary may also be of interest to many who have not read the lecture itself; as we do not remember ever to have seen so large an accumulation of facts relative to loading, patterns, velocities, &c., compressed into so small an amount of space.

We will commence with the patterns that were given by the three kinds of barrels—the first of which was a choke, wherein the gauge towards the breech is ·740 inch (the widest limit of a 12 bore), but reduced at the muzzle to ·706 inch (or nearly 14 gauge). The second, or "nominal cylinder"—or what is also known as an "improved cylinder" or "modified choke"—was reduced from ·740 inch at breech to ·717 inch (or 13 gauge) at muzzle; and the true cylinder gun was ·734 inch at both breech and muzzle. We may add that any barrel measuring between ·740 and ·720 at nine inches from the breech would be proved as a 12-bore, no matter how much it may be contracted at the muzzle.

The following list describes the eighteen methods of loading used in the course of these experiments:

1. The old "Field" black-and-pink wad (of 11½ gauge, and about ¼ inch in thickness), with $\frac{1}{16}$ inch felt and thin card over the powder and thick card over the shot; turnover fair (about ½ inch).
2. Mr Griffith's "Field" card (about half the thickness of the old wad), and ⅛-inch felt; the rest of the wads as above.
3. Same as No. 2, except that the card over the shot was thin.
4. Same as No. 3, except that the felt wad was very soft.
5. Four hard black-edge tight-fitting wads on powder, and no felt, with thick card over the shot.
6. Thick card, felt, and thin card over the powder, and thick card over the shot—all the wads being loose enough to drop into the case.
7. Same as No. 2, but the powder wad slanting.
8. Same as No. 2, but all wads slanting, and turnover also oblique.
9. Same as No. 2, but case lightly turned over (about ⅛ inch).
10. Ditto, but very heavy turnover (about ⅜ inch).
11. Same as No. 2, but in 2¾-inch case, used in 2½-inch chamber.
12. Ditto, but 3-inch case used in 2½-inch chamber.
13. Same as No. 2, but with stronger cap.
14. Ditto, but with still stronger cap.
15. Same as No. 2, except powder increased to 45grs., and felt wad reduced to $\frac{1}{16}$ inch, in 2½-inch case.
16. Ditto, but powder increased to 49grs., felt wad increased to $\frac{1}{12}$ inch, and loaded in 2¾-inch case.
17. Same as No. 2, except that the powder used was made specially strong and quick in combustion.
18. Same as No. 2, except that the powder was made specially weak.

For facility of comparison we have numbered the above-mentioned modes of loading, and hereafter give the results of the experiments carried out at an unusually large target, containing in the centre the ordinary 30-inch circle, with an outer ring of 6 feet in diameter. Each variety of loading was tried with the three kinds of barrel, viz., Choke, Nominal Cylinder, and True Cylinder, and we group the results in three columns, showing the respective number of pellets in the smaller circle and the outer ring or belt, together with totals of the two. And as every charge of shot contained 304 pellets, it will be easy to ascertain, from the l st of tota's, how many of the pellets, with the respective charges and different guns, were scattered beyond the limits of the 6ft. target. The following figures represent averages of three or more rounds each:

	30-inch Circle.			6-feet Ring.			Totals.		
No.	Choke.	N.C.	T.C.	Choke.	N.C.	T.C.	Choke.	N.C.	T.C.
1	201	151	114	94	134	150	295	285	264
2	215	159	122	85	126	150	300	285	272
3	218	165	121	78	106	152	296	271	273
4	210	146	120	84	128	147	294	274	267
5	207	163	108	79	106	149	286	269	257
6	108	106	96	142	132	132	250	238	228
7	197	150	119	92	118	146	289	268	265
8	160	121	90	95	127	144	255	248	234
9	210	156	123	79	115	137	289	271	260
10	192	141	118	80	125	135	272	266	253
11	194	153	116	82	120	146	276	273	262
12	178	134	103	95	120	145	273	254	248

The first group of four in the above table all gave good results; whereas the conditions connected with the remaining eight should be carefully avoided.

Throughout the whole series of experiments there were very few departures from the usual charge—viz., 42grs. of Schultze powder with 1⅛oz. of No. 6 shot, loaded in Eley's 2½-inch nitro cases with ordinary caps. But in experiments 11 and 12, longer cartridge cases were used, in order to ascertain the effect of the paper overlapping the cone of the 2½-inch chamber. In Nos. 13 and 14 stronger caps were tried; and in Nos. 15 and 16 increased charges of powder were used without any increase in the shot charge. And, finally, in Nos. 17 and 18 two special samples of powder were employed, one strong and the other weak. The results of these various changes on the target patterns are shown in the next table:

	30-inch Circle.			6-feet Ring.			Totals.		
No.	Choke.	N.C.	T.C.	Choke.	N.C.	T.C.	Choke.	N.C.	T.C.
13	215	161	120	83	128	149	298	289	269
14	212	154	118	80	122	140	292	276	258
15	192	147	116	92	123	148	284	270	264
16	182	136	111	91	117	140	273	253	251
17	181	140	111	85	107	135	266	247	246
18	185	160	128	96	121	150	281	281	278

But, although the above tables suffice to show the extent of numerical variation in the average patterns, it is necessary to refer to Mr Griffith's photographs in order to see how widely they differed in the distribution of their pellets—some being very regular in their spread, while others were exceedingly patchy, or disfigured by clusters of balled shot.

The following table, however, provides a better opportunity of studying cause and effect:

No.		Pressure. Tons.	Time in Barrel.	Muzzle Velocity.	Recoil.
	Good Wads and well-loaded Cartridges.				
1	(11½ thick wad)...	3·69	·0056	1208	25·2
2	(11½ card)	2·71	·0056	1230	26·0
3	(thin over shot)	2·65	·0063	1222	26·0
4	(very soft felt)...	2·49	·0066	1215	24·8
	Very Tight and Very Loose Wads.				
5	(tight)	3·77	·0048	1294	30·6
6	(loose)	2·18	·0060	926	20·1
	Crooked Wads.				
7	(one)	2·70	·0056	1188	26·2
8	(all)	2·76	·0060	1115	25·5
	Light and Heavy Turnover.				
9	(light)	2·13	·0067	1198	25·0
10	(heavy).....	3·06	·0054	1205	26·6
	Cases Longer than the Chamber.				
11	(2¾in.)	3·22	·0052	1237	28·7
12	(3in.).....	3·71	·0048	1261	30·2
	Difference in Strength of Caps.				
2	(ordinary)	2·71	·0056	1230	26·0
13	(medium)	2·75	·0046	1237	25·9
14	(strong)	2·82	·0042	1236	26·3

INCREASED CHARGES OF POWDER.

No.		Pressure. Tons.	Time in Barrel.	Muzzle Velocity.	Recoil.
2	(42grs.)	2·71	·0056	1230	26·0
15	(45½grs.)	3·23	·0055	1274	29·6
16	(49grs.)	3·87	·0069	1328	33·9

POWDERS OF DIFFERENT STRENGTH.

2	(ordinary)	2·71	·0056	1230	26·0
17	(stronger)	3·28	·0048	1249	28·1
18	(weaker)	1·83	·0079	1081	22·6

Here we see at a glance how a variation in the wads, the amount of turnover, &c., affects the amount of pressure in the barrel, velocity, and recoil, even when the charge of powder and shot is exactly the same.

In the first batch of four in the above table—all of which are examples of good loading—it will be seen that the pressures do not differ very widely, neither does the time in the barrel, the muzzle velocity, or the recoil.

On looking at Nos. 5 and 6, however, it becomes at once obvious that the exceedingly tight hard wads have raised the pressure by more than a ton, thereby lessening the time in the barrel, increasing the muzzle velocity and also adding to the recoil. The safety of the gun is risked by an increase of about 40 per cent. in the stress within the barrel, the muzzle velocity is raised about 8 per cent., and the recoil increased about 18 per cent. On the other hand, the use of very loose wads lessens the pressure considerably, and reduces the velocity by about 300 feet per second; consequently the recoil (which with the well-loaded cartridges was about 25 or 26 ft.lb.) is lowered to about 20; while with the excessively tight wads it rises above 30 ft.lb.

With the crooked wads (Nos. 7 and 8) the chief effect is to spoil the pattern, the velocity and recoil being less interfered with. And much the same may be said of the deficient and the excessive amount of turnover (Nos. 9 and 10), except that the heavy one causes nearly a ton greater pressure in the barrel than is given by the light turnover.

When long cases are used in short chambers, the paper overlaps the cone and causes greater resistance to the passage of the shot and wads. The pressure then goes up considerably (see Nos. 11 and 12), and the time in the barrel is shortened, while muzzle velocity and recoil are both increased. And the longer the cartridge case, the more marked are these effects.

The ordinary caps of Eley's make are taken to represent 100 units of strength, the medium being equal to 150, and the strong caps to 180 units. With each increase of strength in the caps there was an increase of pressure and a shortening of time in the barrel; but the muzzle velocity and recoil varied very little.

When, however, increased charges of powder were employed, the pressures went up considerably, and so did velocity and recoil; yet the time in the barrel was lengthened with the largest charge (No. 16), probably owing to its being requisite to use a 2¾-inch case with thicker felt wad.

The specially strong and weak samples of powder (Nos. 17 and 18) may naturally be expected to give very different pressures from those exhibited by the ordinary powder with a similar kind of loading. The strong sample showed exactly the same time in the barrel as the excessively tight wads used in experiment No. 5; but the pressures, muzzle velocity, and recoil were not so high. And the weakest powder recorded the longest time in the barrel in the whole series; but the muzzle velocity and recoil were not nearly so low as with the loose wads (No. 6), although the pressure recorded was nearly a ton less.—ED.

SIZES OF SHOT, AND THEIR VELOCITIES.

(*Field*, May 25, 1889; Vol. 73, p. 725.)

QUESTIONS are not unfrequently asked as to the reasons why guns are ordinarily tried with No. 6 shot, rather than with other sizes which may be preferred by the respective querists. We can only say that the subject was discussed in the early days of *Field* Gun Trials, and the general consensus of opinion appeared to be in favour of No. 6. And, a standard of comparison having once been established, it is undesirable to abandon that standard for another; although other lines of comparison may occasionally be introduced with advantage.

Few persons have any distinct notion of the differences of velocity that occur with pellets of different sizes, and we therefore summarise some particulars in the following short table:

Here the "Mean Velocity" means the average speed (in feet per second) for a range of 40 yards; and the "Striking Velocity" means the velocity remaining in the shot at the end of the 40 yards. It will be observed that there are three different charges used, with shot of eight sizes; and the charges may be taken as typical representatives of those producing high, medium, and low velocities.

Size of Shot.	3 DRS. AND 1 OZ. Muzzle Velocity.	Mean Velocity.	Striking Velocity.	3 DRS. AND 1⅛ OZ. Muzzle Velocity.	Mean Velocity.	Striking Velocity.	2½ DRS. AND 1 OZ. Muzzle Velocity.	Mean Velocity.	Striking Velocity.
No. 1	1220	*1013*	804	1202	*950*	760	1065	*883*	718
,, 2	1215	*980*	758	1195	*920*	713	1060	*868*	695
,, 3	1205	*946*	723	1189	*900*	693	1046	*848*	662
,, 4	1202	*918*	690	1171	*872*	653	1035	*833*	638
,, 5	1200	*892*	649	1167	*865*	638	1025	*805*	615
,, 6	1198	*872*	626	1160	*840*	604	1020	*796*	587
,, 7	1192	*845*	588	1135	*803*	577	1006	*770*	545
,, 8	1185	*815*	557	1126	*785*	532	996	*740*	508

The first-mentioned charge, of 3drs. powder with 1oz. shot, produces very nearly the same speed as 3¼drs. powder and 1⅛oz. shot; or 4drs. powder and 1¼oz. shot. The latter two have a slightly larger proportion of powder than the first, but the difference in velocity is not very great. The second in the list—3drs. powder and 1⅛oz. shot—is almost identical, as regards velocity, with 3½drs. and 1¼oz. And the third is lower in its proportion of powder than is ordinarily used, but serves to mark the characteristics of low velocities better than intermediate charges, which run so closely together as to be rather confusing. The above charges were all fired from the same gun, a chokebore of 12 gauge, with Newcastle chilled shot; and the velocities stated are in all cases the averages obtained by firing several rounds.

The chronograph velocities of small shot ordinarily published are merely records of the observed or mean velocity for a stated distance; and in the above table they are printed in *italic* figures for the sake of distinctiveness. Such records afford but a very imperfect idea of the speed of the shot on leaving the gun, or that with which it reaches the target; for the mean velocity of the whole distance is not necessarily midway between the two extremes. With bullets, whether spherical or elongated, the muzzle velocity and the striking of remaining velocity may be directly calculated from the mean velocity, owing to the regular reduction in speed of a single projectile. But the shifting character of the charge of small shot does not permit of the same process being adopted, and the velocities at the muzzle of the gun and the end of the range can only be indirectly estimated.

The course adopted for the above table was as follows:—For muzzle velocity, the observed or mean velocity for the first five yards from the muzzle, as taken by chronograph, was made the basis; and the velocity lost during those five yards was taken as intermediate between what the loss would have been with a solid bullet of the full weight of the shot-charge, and what it would have been with a single pellet of the shot used. The charge of shot leaves the gun in the form of a flat headed cylinder, and the air-resistance to a flat-headed cylinder has been found to be just about double that of a bullet with an ogival head; so we first tried the effect of allowing double the amount of speed that would be lost by a solid bullet of the full size of bore. That allowance seemed to be satisfactory as regards the largest size of shot; but, the allowance being uniform for all sizes, what would suit No. 1 was insufficient for No. 6 or No. 8, which obviously were more retarded by the spread of pellets that occurs even in so short a distance as five yards. We accordingly substituted the mean between bullet and pellet, which varies little from the other method as regards large shot, but makes for the small pellets an allowance that corresponds with the loss which is indicated by the chronograph times.

For the striking or remaining velocity at 40 yards, a less elaborate process was necessary; for, although the speed at that distance could not be directly observed, the times for 35 yards and 45 yards having been ascertained, the mean velocity for the intervening 10 yards (where the pellets are widely scattered, and travelling independently) may be taken as representing the actual velocity at the middle point, or 40 yards; and this is what is given in the table.

The variations with the different sizes of shot, and the different charges, will speak for themselves; and we need only point out how inadequately the striking velocity of the shot is represented by the mean or observed velocity. With some sizes of shot, and some charges, the mean velocity is just about the average between the muzzle and the striking velocities; with others there is a wide difference—the difference being most shown where the pellets are smallest and the proportion of powder used is greatest. The velocities given in the above table are derived from the records of Mr. Griffith's experiments previously stated in fuller detail. T.

THE VARYING VELOCITIES OF PELLETS IN SHOT CHARGES.

(*Field*, Sept. 4, 1897; Vol. 90, p. 197.)

12-BORE GUN.

EVERY shooter knows that, if he wishes to kill his game cleanly, his aim should be "dead on;" that is to say, the game must be struck by as nearly as possible the centre of the pattern made by the shot-charge; because, not only are the pellets more numerous near the centre, but the velocity, and therefore the penetration, is greater.

Last year, with the object of conveying a better idea of the distribution of the pellets, we divided our shot target into six rings, the diameters being respectively 15in., 21½in., 26in., 30in., 33½in., and 36½in., the area of all the rings being alike, viz., 225 circular inches. After some of the trials carried out by means of this target, a correspondent wrote us the following letter:

SIR,—Your recent trials of light-weight guns showed clearly that both 16 and 20 gauges can be bored so as to give a pattern, penetration, and killing circle as good as those of a 12 gauge, when the latter has the same load of shot. But some sportsmen believe that, although the central pellets from a small-bore may have the same velocity as those from a large bore, the outside pellets do not give equal penetration. It seems possible, for mechanical reasons, that this idea may be, to some extent, correct; because the outside pellets of a small gauge must fly at a greater angle than those of a large to reach the circumference of the killing circle. Yet the difference between the angles of either a 20, 16, or 12 is not much, even when fired at twenty yards. I do not see how the difference, if any, in penetration could be ascertained, except by selecting guns of all three gauges with similar killing circles and firing them at thin sheets of cardboard, fully 30in. in diameter, placed a little apart in a rack. I would be glad of your opinion as to whether or not there is likely to be an appreciable difference in the effect of the outer pellets upon game. I have always had a great liking for the 16 gauge, both in muzzle-loading days and afterwards, yet fancy that I have done better work with the 12 gauge, even when loading it with only 1oz. of shot.

J. J. M.

With the view of ascertaining the difference, if any, of the velocities of the pellets striking the various rings, we have constructed an apparatus, in connection with the chronograph, that could be moved to any position on the target. A preliminary trial was made to ascertain whether there was any difference in the velocity of the pellets at top, bottom, right, or left hand sides of the centre of the pattern, in any particular ring; but so little difference was found that it was not worth noticing. In the main trial, twenty records were obtained from each of the rings with the cylinder barrel, and a like number from the choked barrel.

It is well known that variations in atmospheric conditions have considerable influence on the velocities of shot pellets; and, in order to eliminate as far as possible the disturbing effects of such atmospheric changes during the trial, only four rounds were at first fired from the cylinder and four from the choke at the centre circle; and then, as quickly as possible, each of the circles was dealt with in the same way. As soon as all the rings had been thus fired at, the centre one was attacked with another four rounds from each barrel; and so on until twenty records from each barrel at each of the circles were obtained. During the trial the height of the barometer averaged 29·70in.; while the thermometer averaged 50° with the dry bulb and 63° with the wet. As the experiments extended over several days, there were some slight variations, but they were not of sufficient importance to record separately.

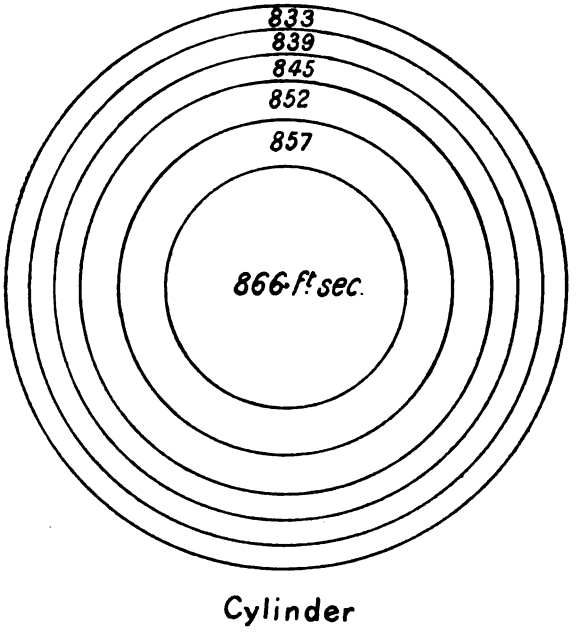
MEAN VELOCITIES IN 40 YARDS RANGE.

First Ring.		Second Ring.		Third Ring.	
CYLINDER.	CHOKE.	CYLINDER.	CHOKE.	CYLINDER.	CHOKE.
871 ft.sec.	869 ft.sec.	851 ft.sec.	877 ft.sec.	861 ft.sec.	853 ft.sec.
853 "	887 "	862 "	856 "	857 "	864 "
878 "	858 "	871 "	878 "	850 "	862 "
862 "	872 "	858 "	863 "	837 "	849 "
871 "	864 "	849 "	858 "	846 "	871 "
870 "	875 "	865 "	873 "	853 "	865 "
862 "	885 "	868 "	860 "	862 "	858 "
855 "	868 "	889 "	871 "	851 "	860 "
877 "	876 "	854 "	862 "	860 "	848 "
867 "	880 "	862 "	875 "	836 "	862 "
875 "	862 "	857 "	868 "	844 "	855 "
858 "	873 "	851 "	851 "	864 "	873 "
868 "	885 "	860 "	870 "	844 "	857 "
871 "	888 "	854 "	864 "	857 "	870 "
873 "	867 "	846 "	861 "	863 "	855 "
865 "	855 "	866 "	855 "	850 "	861 "
870 "	874 "	850 "	871 "	853 "	853 "
855 "	880 "	870 "	866 "	856 "	866 "
867 "	868 "	848 "	850 "	848 "	849 "
860 "	884 "	853 "	878 "	842 "	851 "
866 Averages	874 "	857 Averages	865 "	853 Averages	859 "

MEAN VELOCITIES IN 40 YARDS RANGE.

Fourth Ring.		Fifth Ring.		Sixth Ring.	
CYLINDER.	CHOKE.	CYLINDER.	CHOKE.	CYLINDER.	CHOKE.
851 ft.sec.	858 ft.sec.	840 ft.sec.	849 ft.sec.	825 ft.sec.	834 ft.sec.
828 "	864 "	838 "	850 "	848 "	854 "
850 "	844 "	832 "	844 "	840 "	840 "
837 "	851 "	855 "	838 "	836 "	826 "
864 "	856 "	840 "	831 "	823 "	838 "
851 "	849 "	833 "	853 "	838 "	860 "
855 "	862 "	836 "	846 "	833 "	839 "
839 "	855 "	850 "	830 "	843 "	840 "
842 "	850 "	823 "	844 "	834 "	859 "
822 "	864 "	843 "	828 "	836 "	836 "
836 "	861 "	838 "	851 "	829 "	844 "
856 "	858 "	834 "	846 "	836 "	851 "
860 "	843 "	840 "	857 "	845 "	826 "
844 "	860 "	853 "	842 "	828 "	861 "
835 "	844 "	848 "	836 "	836 "	836 "
824 "	846 "	833 "	861 "	834 "	830 "
855 "	863 "	842 "	853 "	824 "	844 "
862 "	856 "	837 "	840 "	838 "	832 "
857 "	866 "	829 "	862 "	836 "	836 "
840 "	840 "	840 "	829 "	825 "	842 "
845 Averages	850 "	839 Averages	845 "	833 Averages	841 "

The following illustrations show the appearance of the rings upon the target, as well as the relative mean velocities recorded with the cylinder and choked barrels. The conical figure is a hypothetical representation of the shot-charge as it approaches the target:



The gun used in these experiments was a 12-bore of 7lb. weight; right barrel, cylinder; left barrel, choke; with 3drs. of No. 4 black powder and 1⅛oz. No. 6 shot; wadding, thin card over powder, then ⅛in. soft felt and grey cloth wad, with thin card over shot; Eley's green cases. Average patterns in 30in. circle, 130 with the right and 175 with the left.

It will be noticed by referring to the tables that the velocity of the pellets gradually fell off as the centre was receded from; and the loss of speed between the respective rings will be shown by the following summary:

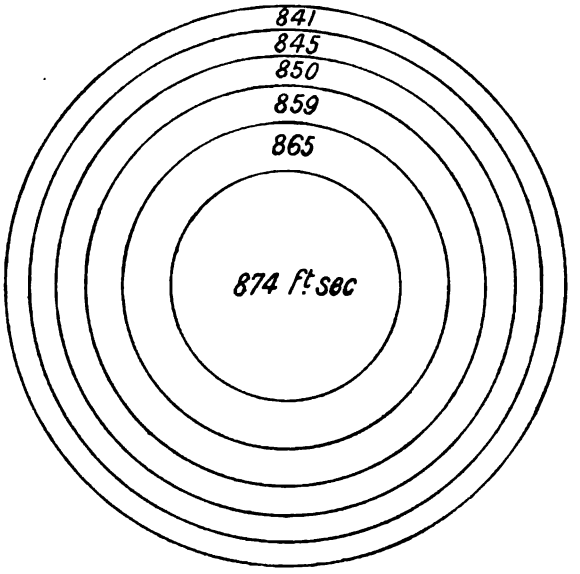
MEAN VELOCITIES FOR 40 YARDS, IN FEET PER SECOND.

	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.
Cylinder barrel	866	857	853	845	839	833
Choked barrel	874	865	859	850	845	841

With both barrels, it will be seen, there was a continuous diminution in speed as the pellets spread wider and wider from the centre of the target—the difference between the first and the sixth ring amounting to 33 ft.sec. in both instances, or a reduction of about 4 per cent.

This percentage alone, however, gives a very inadequate idea of the loss of force at the outer ring as compared with that portion of the charge which is in the centre. The velocities recorded in the respective rings represent the *mean speed* for the entire range (40 yards). But it must be remembered that the velocity of the shot, *as it leaves the mussle of the gun*, would be virtually equal with the entire charge (whether fired from cylinder or choked barrel), however much the individual pellets may eventually vary when they afterwards strike the target; and it may be remarked that a difference in the *mean* velocity for 40 yards would be practically equivalent to about double as much difference in the *final* velocity of the outside pellets, which suffer the greatest amount of retardation by the resistance of the atmosphere.

Thus, supposing the mussle velocity of a charge of No. 6 shot to be 1200 feet per second, the mean velocity for 40 yards would be about 850 ft.sec., while the striking velocity, on reaching the target, might be about 600 ft.sec. The pellets in the centre, however, having about



Choke.

30 ft.sec. greater mean speed than those in the outer ring, would have about 60 f.s. higher velocity at the finish; consequently, if the final velocity of the central pellets were 600 ft.sec., that of the outside pellets would only be about 540 f.s. And, as the energy or striking force of the pellets varies as the square of their velocity, there would be a corresponding reduction in the force of those placed in the outside ring.

The average energy per pellet, in the respective rings, with the cylinder and choked barrels, is set forth in the next table, together with the number of pellets, as ascertained in some previous experiments with the same gun. And, on multiplying the energy per pellet by the number of pellets placed in the rings, the results, with No. 6 shot, come out as follows:

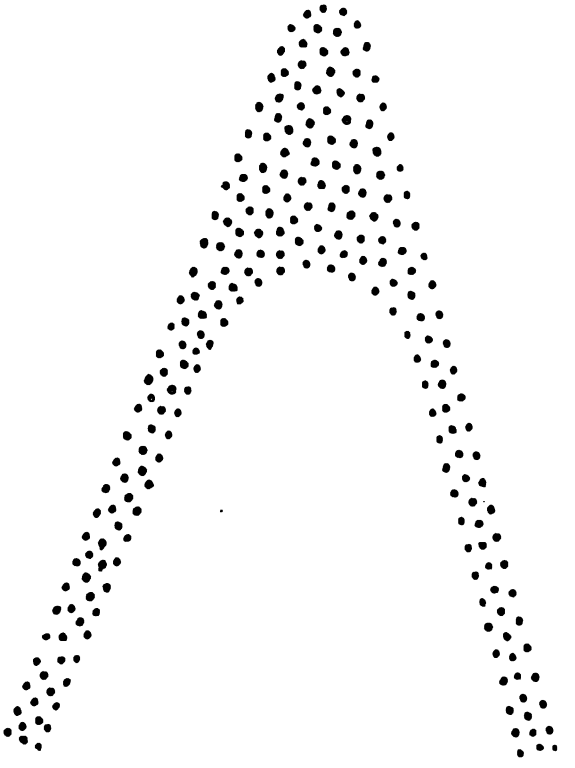
CYLINDER BARREL.

	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.
Energy in ft.lb.....	1·26	1·22	1·17	1·13	1·09	1·05
Number of pellets ...	39	30	25	21	16	16
Total Energy.....	49·1	36·6	29·2	23·7	17·4	16·8

CHOKED BARREL.

	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.
Energy in ft.lb.....	1·30	1·26	1·22	1·17	1·13	1·09
Number of pellets ...	63	47	33	25	21	15
Total energy.....	81·9	59·2	40·2	29·2	23·7	16·4

From this it will be seen that, with the cylinder barrel, the chance of killing a bird with the centre of the charge, as compared with that of the outer ring of the target, is as 49·1 to 16·8, or about 3 to 1, with the cylinder barrel. And with the choked barrel it is 81·9 to 16·4, or about 5 to 1.



PROBABLE HOLLOW CONICAL FORM OF A CHARGE OF SHOT AT 40 YARDS.

These results show how important it is that sportsmen should be accurately fitted with their guns, to ensure as far as possible a correct and instantaneous alignment, so that the game may be struck by the centre of the pattern.

(*Field*, Oct. 16, 1897; Vol. 90, p. 606.)

20-BORE GUN.

IN our issue of Sept. 4 we published particulars relative to experiments which we had carried out with a 12-bore gun, for the purpose of ascertaining the difference of velocity between the outside pellets of the charge, as compared with those in the centre of the pattern. We have since tried similar experiments with a gun of 20-bore, using, of course, a smaller charge of powder and shot. The particulars relative to the gun and loading are as follows:

20-bore gun, lent by Mr Leeson, gunmaker, of Ashford, Kent; weight 5lb. 18oz., length of barrels 29 inches, right cylinder, left choke; 65grs. of No. 4 black powder and ¾oz. of No. 6 shot. Wadding: Thin card over powder, ¾in. felt, thin card, and thin card over shot. (Barometer, 29·64; thermometer—dry 57°, wet 55°).

MEAN VELOCITIES IN 40 YARDS RANGE.

First Ring.		Second Ring.		Third Ring.	
CYLINDER.	CHOKE.	CYLINDER.	CHOKE.	CYLINDER.	CHOKE.
858 ft.sec.	848 ft.sec.	863 ft.sec.	868 ft.sec.	860 ft.sec.	857 ft.sec.
857 "	877 "	846 "	855 "	855 "	850 "
873 "	877 "	853 "	867 "	840 "	849 "
870 "	838 "	838 "	858 "	853 "	855 "
870 "	861 "	857 "	849 "	851 "	839 "
846 "	849 "	840 "	862 "	846 "	842 "
853 "	848 "	839 "	870 "	850 "	855 "
834 "	855 "	861 "	853 "	842 "	862 "
861 "	868 "	850 "	867 "	836 "	846 "
867 "	857 "	842 "	855 "	843 "	853 "
853 "	870 "	829 "	861 "	840 "	848 "
848 "	865 "	865 "	865 "	848 "	865 "
867 "	878 "	840 "	858 "	837 "	840 "
855 "	858 "	857 "	872 "	853 "	848 "
843 "	871 "	868 "	840 "	849 "	856 "
863 "	864 "	854 "	851 "	857 "	851 "
838 "	850 "	840 "	842 "	851 "	856 "
853 "	877 "	858 "	854 "	849 "	844 "
846 "	844 "	870 "	863 "	836 "	854 "
868 "	860 "	837 "	844 "	840 "	862 "
855 Averages	861 "	850 Averages	858 "	847 Averages	853 "

Fourth Ring.		Fifth Ring.		Sixth Ring.	
CYLINDER.	CHOKE.	CYLINDER.	CHOKE.	CYLINDER.	CHOKE.
850 ft.sec.	848 ft.sec.	840 ft.sec.	842 ft.sec.	826 ft.sec.	839 ft.sec.
838 "	840 "	844 "	839 "	832 "	821 "
842 "	837 "	832 "	828 "	823 "	840 "
846 "	851 "	829 "	836 "	821 "	834 "
851 "	843 "	842 "	846 "	819 "	833 "
835 "	849 "	836 "	836 "	829 "	825 "
844 "	853 "	829 "	826 "	834 "	839 "
833 "	850 "	831 "	840 "	822 "	820 "
846 "	846 "	833 "	837 "	831 "	826 "
843 "	837 "	838 "	843 "	828 "	832 "
833 "	843 "	830 "	836 "	824 "	821 "
853 "	844 "	824 "	833 "	830 "	838 "
846 "	839 "	835 "	842 "	825 "	829 "
837 "	842 "	842 "	834 "	822 "	825 "
842 "	849 "	836 "	838 "	833 "	833 "
836 "	838 "	825 "	845 "	836 "	821 "
840 "	840 "	829 "	833 "	820 "	839 "
848 "	845 "	831 "	840 "	817 "	830 "
832 "	854 "	834 "	831 "	836 "	828 "
851 "	844 "	830 "	828 "	821 "	834 "
842 Averages	845 "	833 Averages	837 "	826 Averages	830 "

There is not much difference in the amount of reduction of velocity with the outside pellets of the 20-bore (using ¾oz. of shot) as given in the above tables, and that shown in our previous article with the 12-bore gun (using 1¼oz. of shot). A comparison of results may be made in the following summary:

MEAN VELOCITIES IN 40 YARDS RANGE.

12-BORE.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Greatest difference.
Cylinder barrel	866	857	852	845	839	833	33
Choke "	874	865	859	850	845	841	33
20-BORE.							
Cylinder barrel	855	850	847	842	833	826	29
Choke "	861	858	853	845	837	830	31

Some persons are of opinion that, with a diminution in the size of the bore, there must be a greater amount of "tailing off" or "stringing" in the shot-charge. But the above figures go to show that, for all practical purposes, the results are the same; and what difference is here recorded is slightly in favour of the smaller bore.

(*Field*, Sept. 18, 1897; Vol. 90, p. 464.)

SIR,—Your experiments (recorded above, pp. 249—250) with the choked barrel give the mean velocity of the shot striking the centre of the target as 874 ft.sec., that of the outside pellets at 841 ft.sec. Then the time taken by the centre pellets is ·1373 sec., while the outside pellets only reach the target in ·1426 sec., which is ·0053 sec. later. They are then travelling at the rate of 540 ft. per second, so that they are about 2·9 ft. behind the centre pellets.

The experiments made by Mr. R. W. S. Griffith, and recorded by you in a previous volume, of which I regret I cannot give you the date, show that the time the centre pellets would take to go from 40 yards to 60 yards would be ·123 sec. If the outer pellets have at 40 yards 60 ft.sec. less velocity than the centre, they will lose ·123 of 60 ft. = 7·38 ft., which, added to the loss they had already made at 40 yards, puts them 7·38 + 2·9 = 9·47 ft. behind the centre pellets. Apparently they would take about $\frac{1}{10}$ sec. to get this distance.

Now, in $\frac{1}{10}$ sec. a bird crossing at 15 yards per sec. flies half a yard; and allowing for the increased spread of the shot at 60 yards, if the centre pellets pass just behind his tail, then the outside pellets will do so too; by the time they reach 60 yards the bird will be clear of the killing circle.

But if, as seems probable, the velocity of the centre pellets should exceed that of the outside by more than 60 ft.sec. at 60 yards, or if the bird should travel faster than 15 yards per second; then, the point at which you would miss him entirely if you put the centre pellets behind him would be nearer than 60 yards. My figures may be wrong, but it looks as if this must occur at some point between 40 and 60 yards. Of course, if the centre pellets are just in front of the bird, you may hit him with the outside pellets.

Would the outside pellets drop much more than the centre?

Brashfield, Bicester, Sept. 14, 1897. E. A. BURCHARDT.

(*Field*, Sept. 25, 1897; Vol. 90, p. 504.)

SIR,—In his interesting little letter (printed above), Mr E. A. Burchardt asks: "Would the outside pellets drop much more than the centre?"

The data requisite to give a definite answer to this question may be found in the records of an admirable series of experiments carried out by Mr R. W. S. Griffith about ten years ago, and published in an article entitled "The Spread of Pellets in Shot Charges," inserted in the *Field* of April 9, 1887. In these records, with 3drs. of powder and 1¼oz. of No. 6 shot (in the choked barrel of a 12-bore gun), the time taken by the fastest pellets in traversing the distance of 40 yards was ·1357 second, while the slowest pellets in the same charge took ·1717 sec. to accomplish the same distance. In these times, under the action of the force of gravity, the fastest pellets would drop rather more than 3¼in., and the slowest pellets rather more than 5¼in. Ordinarily, shot guns are so sighted as to allow for a drop of about four inches in 40 yards.

Supposing, however, that the gun were fired at an object more than 40 yards distant, the time of flight of the shot would necessarily be lengthened. Indeed, it would take nearly twice as long for a charge of No. 6 to go 60 yards as it would to traverse only 40yds.; and as the "drop" increases in proportion to the "square" of the time, it would thus be about four times as great in 60yds. as in 40yds.

From Mr Griffith's records it appears that the actual time for 60yds. with the fastest pellets was ·2668 sec., for which the equivalent drop is nearly 17½in.; whereas the time with the slowest pellets was ·3208 sec., equivalent to a drop of nearly 20in. Thus the ratio of increase was not uniform with the two batches of pellets, as with the fastest batch the drop in 60 yards is about five times as great as in 40 yards, whereas with the slowest pellets the drop increases in a smaller ratio, viz., 3½ to 1 instead of 5 to 1.

This apparent anomaly is to be accounted for by the fact that the pellets which move fastest would undergo the greatest amount of retardation by atmospheric resistance, as will be seen by the following mean velocities of the fastest and slowest pellets in the same charge at various distances.

	Fastest pellets.	Slowest pellets.	Differences of retardation.
At 10 yards.	1132 ft.sec.	896 ft.sec.	236 ft.sec.
" 20 "	1073 "	852 "	221 "
" 40 "	884 "	699 "	185 "
" 60 "	675 "	561 "	114 "

These records of Mr Griffith's (which were made by means of a revolving target) are most valuable, and when studied in connection with the recent experiments recorded in the *Field* of the 4th inst., the one set of figures assists in the elucidation of the other. Mr Griffith's illustrations clearly show how greatly a shot-charge "strings" or "tails off" during its flight through the air; but it is not obvious (although it may be inferred) that the slowest pellets are those which are farthest from the centre of the circle. The recent *Field* experiments (which were carried out by means of a fixed target divided into concentric rings) demonstrate that the slowest pellets are those farthest from the centre of the charge; but as the *Field* target was only about 3ft. in diameter, whereas Mr Griffith's was 4ft., the larger target took a much greater proportion of the shot charge, and consequently showed that there was more falling off in velocity at the edge of the 4ft. target than was observed on that which was a foot less in diameter. T.

(*Field*, Oct. 2, 1897; Vol. 90, p. 537.)

SIR,—I am obliged to your correspondent T. for his reply to my question regarding the drop of pellets. I was curious to know if any large proportion of the pellets forming the centre of a pattern could be outside pellets which had dropped from the top of the charge and arrived at the plate later than the centre pellets. It would appear from T.'s reply that this is not the case.

Turning to Mr Griffith's experiments, it appears that at 40 yards the fastest pellets had a mean velocity of 884 ft.sec., and the slowest of 699, giving times of flight of ·1717 and ·1357 sec., the difference of time being ·036 sec. At 60 yards the velocities were 675 and 561 ft.sec.; the times ·3209 and ·2666 sec., and the difference ·0543 sec.—just half as much again as at 40 yards. It is difficult to compare these results with yours, taken on a different target; but I think they support the point I raised in my previous letter—that the difference in the times between the centre and outside pellets may be such that if you are behind a crossing bird with the former you will not catch him with the latter, for at 15 yards per second a bird would fly 19 in. in ·036 sec., or 29 in. in ·054 sec.; and, if this is so, the pattern of a gun as usually obtained on a stationary target cannot give us any accurate idea of its effective killing circle. E. A. BURCHARDT.

Bicester, Sept. 28, 1897.

SIR,—The perusal of that lucid and instructive letter on this subject by your correspondent T. recalled a matter that I have long had in my mind. T. speaks of the effect, and, with your permission, I will say something as to the cause, of this variation in speed of flight of the pellets composing a charge of small shot. I am strongly of the opinion that a very great percentage of the slowest pellets will be found to be disfigured. This may not account for the whole of the stringing which takes place, for there must always be some tailing off where the pellets vary in weight; but we may, I think, assume that a battered, shapeless mass of lead will neither fly so far nor preserve so true a course as a more spherical pellet. A few shots fired at the card rack used for testing the penetrative force of the pellets convinces one that the penetration exhibited is proportionate to the rotundity of the shot. In the course of some experiments with wildfowl guns, the results of which were recorded in the *Field* two or three years ago, I found that this was most marked; for it was at once noticeable that some disfigured pellets did not get through half the number of sheets pierced by more perfect missiles. In the *Field* of July 27, 1895, I remarked on the fact that now and again one hears of a gun possessing the reputation of being a marvellously clean-killing and hard-hitting weapon, and I am still of the opinion that a gun of the kind, on being tested against an arm admittedly its inferior in the matter of killing properties and length of range, would be found not to be so much superior in respect of muzzle velocity as in non-liability to injure the pellets of the shot charge. It is, of course, at the longer ranges that this tailing off is most to be observed. I have found, on firing 8-bore duck guns at the card rack at 60 yards range, that, whilst perfectly spherical pellets of No. 1 shot pierced up to thirty sheets of strawboard, misshapen pellets frequently stopped before they had got through half that number of sheets. I have already made some mention in these columns of the causes which contribute largely to the crushing of the pellets within a gunbarrel. Possibly the following are some of the most important:

1. An abnormally violent jamming together of the pellets in the cartridge case on the first impact of the powder explosion, and which may be caused by the rapid combustion of an exceptionally quick powder, assisted, perhaps, by an excessive turnover of case, by very tight-fitting wads, or by an ill-proportioned load.
2. An ill-formed and badly-designed or defective shoulder or cone at the end of the cartridge chamber.
3. The enormous pressure brought to bear upon the shot by a severe or abrupt method of choking the barrels.

Of course, the friction to which the outside pellets of a charge are subjected in passing along a gunbarrel tends to distigure them, but this may be readily estimated by an examination of the facets on these pellets.

It would, I think, serve an excellent and most useful purpose if further inquiry were to be made into this matter, in order to see which of the foregoing causes contributes most to the disfiguration of the shot pellets. Some valuable lessons would assuredly be taught by experiments having for their object the discovery of a remedy for unnecessarily harsh treatment of the shot. Some may argue that guns kill quite far enough as it is. Possibly that is so; still, I think that it is possible to make guns kill game with far greater certainty at, say, 40 yards, than at present is the case. I should much prefer to see game killed cleaner or missed oftener. HENRY SHARP.

TESTING THE PATTERNS OF SHOT GUNS.

(*Field*, Nov. 14, 1896; Vol. 88, p. 773.)

SIR,—I notice you use rings now when testing the patterns of a gun. Do you not think that, if small squares were rolled on the paper when it is made, a much more reliable test could be made? If every small square without a pellet were penalised, we would not see such patchy patterns. At present, so long as a gun puts on the number of pellets, they can be in groups of five and six. If the above test came in, makers would give more attention to evenness of pattern, perhaps, than they do at present.

Dunedin, New Zealand, Oct. 1, 1896. A. M'CARTHY, Gunsmith.

SIR,—Like other devotees of the gun, I fully appreciate the great improvement in your system of registering patterns of shot guns by the introduction of a series of circles within the 30 or 36 inch circle, as the case may be. This improvement has, I doubt not, been introduced on account of the appreciation of the fact that the great desideratum in pattern is an even distribution of the pellets over a given area.

It has occurred to me that this point might perhaps be more clearly brought out and registered by dividing the 30in. circle (or other given area) into square inches (or larger or smaller squares as you think best), and then counting the squares struck by a pellet or pellets. For example, suppose the 30in. circle divided into square inches (706 squares), and 120 squares being struck by a given discharge, then +120 or −586 would be the numerical record of pattern for that shot. Or you could treat each of your newly-introduced concentric areas in this manner. J. COWPER.

[It is curious that two letters, making similar suggestions, should reach us in the same week, one from New Zealand and the other from the South of England. The idea of dividing the target into small squares, however, is no novelty. Mr. Lincoln Jeffries, of Birmingham, has for years past sold paper targets with such divisions printed upon them; and to the professional gunmaker, desirous of carefully comparing the performances of guns that he has made, or a sportsman fond of target experiments, and anxious to discover which powder or what charges would be most suitable to a gun that he has purchased, these divided targets may prove very serviceable. For purposes of publication in a newspaper, however, we have never been able to see how such targets could be turned to practical advantage, or we should have used them. The records of the trials of 12, 16, and 20-bore guns which we have recently published required large masses of figures to set them forth, although there were only six divisions in the target; but what would these be in comparison with the 706 divisions proposed by Mr. Cowper? And unless details were published, the mere totals would be incomprehensible, or even misleading, as two groups of pellets of similar character might be represented with very different values in the score, if totals alone were printed. In our opinion, the only efficient way of presenting the results to the public would be by giving a photographic representation of each pattern. But to do this the amount of space required would be prohibitory. In our recent trials of 12, 16, and 20-bore guns, if the targets were reduced to a hundredth part of their original size, ten pages would be filled with copies of the patterns of a single gun—and there were nearly thirty guns tested. In case, however, any of our readers should wish to try the system for their own guns, we would advise them to write to Mr. Lincoln Jeffries, 121, Steelhouse-lane, Birmingham, for some of his targets. The width of the squares is 1½ inches, so that the area of each is 2¼ square inches; and with 1½ ounces of No. 6 shot (304 pellets) there would be one pellet to nearly every square if the whole charge happened to be evenly distributed—which, we need hardly say, never does happen.—ED.]

NARROW ESCAPE FROM A BURST BARREL.

(*Field*, Nov. 6, 1897; Vol. 90, p. 737.)

SIR,—I have been rabbit shooting with Kynoch's patent grouse ejector brass-bound cartridges, which I find the very best cartridges I ever used, loaded with No. 6 shot.

After firing twenty successive shots out of the right-hand barrel only, I had occasion to take out both cartridges, when I found the shot wad of the left barrel cartridge had come out of the case, and had slipped down as far as the choke, and the charge of shot was rattling loose in the barrel, held up by the wad.

I shall be glad if you will kindly give me your opinion as to whether this was produced by the concussion caused by constant firing of the right barrel, and whether, had I been obliged to fire off the left barrel, it would have resulted in bursting my gun? [Yes.—ED.]

I can find no other cartridge among those I have which is badly turned over, and have never had any mishap or misfire with any cartridge of their make before. SANDY.

A SHOOTER'S "READY RECKONER."

(*Field*, Jan. 18, 1890; Vol. 75, p. 101.)

SEVERAL questions which have been addressed to us with respect to the difference of spread of shot-charges from chokebore and cylinder barrels at various distances, the numerical changes of pattern with small and large pellets, the variations of both spread and pattern with guns of different gauge, and so on, have led us to think that it may be of service to some of our readers if we frame for their use a sort of "Ready Reckoner," which will enable them to determine for themselves some of the questions that may arise in their minds.

A man may have several guns, and know about what pattern this gun or that gun will give in a 30in. circle at 40 yards distance with one size of shot; or how far the pattern of the right barrel differs from the left; but he may not see a way of estimating what the width of spread of the charge would be at that or other distances, or what would be the proport onate pattern if he changed the size of his shot. Or, supposing that a 12-bore gun gave a certain pattern in the 30in. circle with 1¼oz. of shot, and a 20-bore or 28-bore gave a similar pattern with ⅞oz. or ¾oz. of the same shot, he might like to know what would be the extent of spread of the respective charges.

The tables which we are about to lay before our readers will, we think, enable them to obtain approximately correct answers to various inquiries of this kind. We say "approximately" because, in the very nature of things, exactitude is out of the question in such matters. A gun cannot be expected to perform with the same regularity as a rule-of-three sum; it will often shoot a little better or a little worse with a change in the size of the shot or the weight of the charge; and for the purpose of these tables it is necessary to assume that the gun shoots with equal regularity under all circumstances, and that the pellets are evenly distributed over the whole area. The number to the ounce also varies somewhat with different makers; here the numbers given are those of shot used in experiments which have been reported on in the *Field*.

The first table shows the extent of spread of a charge of 1¼oz. of No. 6 shot, at different distances, when the pattern in the 30in. circle varies from 100 pellets up to 300, increasing 10 each time. It is not to be supposed that the extremes are very likely to occur with the particular charge here mentioned, but the figures may be useful when calculations from other charges have to be made, as will be described later on. It may perhaps be as well to mention that the line of demarcation between "cylinders" and "choke-bores" is generally taken at about 140 pattern. The real old-fashioned relief-bored cylinder, however, seldom went much beyond 120; and many of the so-called "cylinders" of the present day have a touch of the choke in them, although, through being recessed, it is not apparent to their owners.

In the following table, the diameter of spread of the shot-charge is given in inches to the nearest whole number, the fractions being omitted. If the spread at an intermediate distance is required, as 25 yards, take half that of 50 yards; if 35 yards, add those of 30 and 40 together and divide by 2. If the pattern is an intermediate number between the tens, an allowance may be made if thought necessary; but, generally speaking, the nearest ten will suffice.

SPREAD OF SHOT CHARGE (1¼oz. No. 6) AT DIFFERENT DISTANCES.

Pattern in 30in. circle at 40 yards.	20 yards. Diameter in Inches.	30 yards. Diameter in Inches.	40 yards. Diameter in Inches.	50 yards. Diameter in Inches.	60 yards. Diameter in Inches.
100	26	39	52	65	78
110	25	37	50	62	75
120	24	36	48	60	72
130	23	35	46	58	69
140	22	33	44	55	66
150	21	32	43	53	64
160	21	31	41	52	62
170	20	30	40	50	60
180	20	29	39	49	59
190	19	29	38	48	57
200	19	28	37	47	56
210	18	27	36	46	54
220	18	27	35	45	53
230	17	26	35	43	52
240	17	25	34	42	51
250	16	25	33	41	50
260	16	24	32	40	49
270	16	24	32	40	48
280	16	23	31	39	47
290	15	23	31	38	46
300	15	23	30	37	45

The foregoing table, applying to a single size of shot, and one particular charge, may be read off directly without any trouble; and so may the next table, if one wishes merely to ascertain what would be the numerical proportion of the pattern of one size of shot, as compared with another, when the charges are equal in weight. Thus it may be seen at a glance that, with a gun that gives a pattern of 120 with No. 6, the corresponding pattern with No. 5 would be 97, whereas with No. 8 it would be 200, supposing the gun shot all three sizes equally well. We have put the column representing the No. 6 patterns in bolder type, in order that the figures may be seen more readily, when required to be used in connection with the same numbers in the first table. The horizontal line in bold figures near the bottom of the table gives the number of pellets to the ounce of each size of shot.

RELATIVE NUMBER OF PELLETS WITH DIFFERENT SIZES OF SHOT.

No. 1.	2.	3.	4.	5.	5½.	6.	6½.	7.	8.
35	43	53	64	81	89	100	111	126	167
38	47	57	71	89	98	110	122	139	183
42	52	62	77	97	107	120	133	151	200
45	56	67	84	105	116	130	144	164	217
49	60	72	90	113	124	140	156	176	233
53	64	77	97	121	133	150	167	189	250
56	69	82	103	129	142	160	178	201	267
59	73	88	109	137	151	170	189	214	283
63	77	93	116	145	160	180	200	227	300
66	82	98	122	153	169	190	211	239	317
70	86	103	129	161	178	200	222	252	333
73	90	108	135	170	187	210	233	264	350
77	95	113	142	178	196	220	244	277	367
80	99	118	148	186	204	230	256	290	383
84	103	124	155	194	213	240	267	302	400
87	107	129	161	202	222	250	278	315	417
91	112	134	167	210	231	260	289	327	433
94	116	139	174	218	240	270	300	340	450
98	120	144	180	226	249	280	311	353	467
101	125	149	187	234	258	290	322	365	483
104	129	154	193	242	267	300	333	378	500

The second table, like its predecessor, fulfils one direct purpose which is apparent on the surface; but a combined use of the two tables may render them available for other ends which are not so immediately obvious.

Suppose, for instance, a person says, "I don't want so wide a spread as a cylinder of 120 pattern gives with No. 6 shot at 40 yards, but I should like one which would give a similar pattern at 50 yards, with greater striking force; and I wonder what amount of choke and what size of shot would effect this?" Well, by looking at the second table, it will be seen that a similar pattern (122) would be got with No. 4 shot from a gun which would give a pattern of 190 with No. 6; and on then referring to the first table, it will be seen that a gun which gives the pattern of 190 with No. 6, has a spread of 48in. at 50 yards; which is the same as the spread of the cylinder of 120 pattern at 40 yards. So the two branches of the question are answered exactly. The replies will not be so close in every case, but they may be sufficiently near to be of service.

Again, let us suppose a man to possess three guns, of different size, but each giving about the same pattern on the 30in. target at 40 yards, although loaded with very different charges. Say, for instance, that there is a 10-bore cylinder, which, loaded with 1¾oz. of No. 6, gives a pattern of 160; also that there is a 12-gauge medium choke, giving a pattern of 160 with 1¼oz. of the same shot; and a full-choke 28-bore, giving a pattern of 160 with ¾oz. of No. 6. Although some persons might consider the guns equal, from their giving the same numerical pattern, it is obvious that the larger charge must have a greater killing surface; but what will be the difference?

The reply is, that the spread of the charge from the 28-bore would be about 34in. in diameter; that of the 12-bore would be 41in.; and that of the 10-bore 48in. In short, the 12-bore charge is one-half heavier than that of the 28-bore, and a 41in. circle is one-half larger than that of 34in. In like manner, the 10-bore charge is double that of the 28-bore, and the 48in. circle has double the area of the 34in. circle. The method of working out the results is as follows:

As regards the 12-bore, the spread with 160 pattern is read off at once from the first table, which is framed for the ordinary 1¼oz. charge.

Now as to charges other than 1¼oz. Whatever these may be, they have to be brought into correspondence with that standard charge; and, as the increase or decrease therefrom is usually made by the eighth of an ounce, it is not difficult to convert from one to the

other. Thus, the figure 1 representing the charge of 1¼oz., or 9 such fractions of an ounce; the others, from ¾oz. to 1½oz., will be represented thus:

¾oz.	⅞oz.	1oz.	1⅛oz.	1¼oz.	1⅜oz.	1½oz.
⅔ ...	⅞ ...	⅛ ...	⅑ or 1 ...	9/8 ...	11/8 ...	12/8

And as the pattern of the 10-bore is taken to be 160 with 1½oz. of shot, while that of the 28-bore is 160 with ¾oz., the process of working is merely to multiply the pattern (160) by the top number of the fraction (9), and divide by the lower (which would be 6 for the ¾oz., and 12 for 1¼oz.), when the result would be 120 and 240 respectively. Then, by referring to the first table, it will be seen that the 40 yards spread corresponding to 120 pattern is 48in., which consequently represents the 1½oz. spread of the 10-bore; while that of 240 is 34in., which therefore represents the ¾oz. spread of the 28-bore.

Let us now, in conclusion, see how the process works out in connection with an actual trial of three guns of different bores and charges, which were tested with shot of two sizes. In the *Field* of Nov. 10, 1888, was a report of a trial of a 12-bore, with 1⅛oz. shot, a 24-bore with 1oz., and a 28-bore with ¾oz., the two sizes of shot used being No. 4 and No. 6; all the guns were choke-bores. We give the actual patterns of the guns with No. 6 shot; the extent of spread, as calculated from the tables; and then the calculated as well as the actual patterns with No. 4:

	No. 6 Pattern. Actual.		Calculated Spread.		No. 4 Pattern. Calculated.		Actual.
12-bore (1⅛oz.)	216	.....	36½in.	.....	139	.....	132
24-bore (1oz.)...	185	.....	36in.	.....	119	.....	113
28-bore (¾oz.).....	133	.....	36in.	.....	89	.....	96

Here it will be seen that, owing to the 12-bore being more choked than the other two guns, the spread of the shot was practically the same, although the charge was larger. When No. 4 shot was used, two of the guns scattered the charge a trifle more than No. 6, and so put on the target half a dozen pellets less than the calculated proportion; while the third gun did the reverse, and so put on half a dozen pellets more. But this difference was so trifling that the spread with No 4 would be virtually the same as with No. 6; for so small a number of pellets would only make a difference of a fraction of an inch in the width of spread. T.

SOME NOTES ON NITRO-COMPOUNDS.

(*Field*, Nov. 13, 1897; Vol. 90, p. 780.)

At this season of the year questions not unfrequently crop up as to which is the best powder, which the best size of shot, which the best bore or the best length of barrels, and so on. The general result of such inquiries is to call forth a large number of conflicting opinions, exemplifying the truth of the old saying, "many men, many minds."

The most recent example—arising from the question asked by "Inquirer," a few weeks ago—is no exception to the general rule; for nearly all the nitro powders now in the market have been recommended by one or other of the numerous correspondents who have sent answers to the inquiry. Unfortunately, in their endeavours to say a good word for a favourite explosive, some writers fall into the error of exhibiting *trop de zèle*. For instance, it has been asserted that this or that powder gives "absolutely no recoil." If one were to believe all that has been written on this point, there are various powders which possess this inestimable quality; but, unfortunately, it may be said, of such statements, that they are absolutely untrue. Differences of recoil there are, beyond question, but a total absence of recoil is simply impossible. We do not imagine, however, that the writers of such statements intentionally say what is untrue; we conclude that they are merely using an emphatic form of expression to indicate that they do not feel the "kick" so much with one powder as they do with another, and probably they have no idea of what is the real amount of difference between the two. Besides which, what one person feels, and what is felt by another, depends greatly upon the weight of the gun, the physique of the person using it, and the strength of grip with which he presses the gun to his shoulder.

Many people use very light guns, and do not consider the consequences, in the way of recoil, that ensue from the difference in weight. Last year, in our trial of light 12-bores, with 1oz. of shot, three guns (with almost identically the same velocities) showed the following amounts of recoil:—The heaviest (weighing half an ounce under 6lb.) gave 27·3 ft.lb.; one weighing 5¼lb. gave 30·5 ft.lb.; and one weighing 4lb. 14ozs. gave 32·7 ft.lb. No wonder the last, with so light a weight, was severely felt upon the shoulder. On the other hand, a 7lb. gun, with the same charge and slightly higher velocity, gave only 23·6 ft.lb. of recoil—which would be scarcely felt upon the shoulder with a fair grip, and a gun of 7lb. weight.

If anyone wishes to get a definite idea of what the recoil of his gun really amounts to (when uninfluenced by the strength of grip of the shooter), he may do so by suspending it, muzzle downwards, alongside an upright board marked with feet and inches, and on pulling the trigger (of course taking due precautions to prevent accident) he will find the gun lifted bodily to the height of several feet, by the reaction of the explosion—the height varying with the weight of the gun, the amount of the charge, and the nature of the powder.

Supposing it to be a 7lb. gun, loaded with 3drs. of black powder and 1⅛oz. of shot, the gun will be raised about 5ft. by a fine-grain powder, such as No. 2; or rather less with the coarser kinds. (And 7lb. weight, multiplied by 5ft. lift, is equivalent to 35 ft.lb. of recoil.) If 42grs. of Schultze, or some other of the older nitros, be substituted for black, the lift will be reduced to near about 4ft.; and if 25 or 30 grains of the modern concentrated nitros be used, the lift will be several inches less than with the older nitro-compounds. We have tried experiments of this kind, and have found the records practically the same, whether ascertained by the above tedious process of lifting the gun vertically against the force of gravity, or allowing it to move back horizontally against the mechanism of our recoil gauge. And if a 7lb. gun, with the charges above stated, shows about 28 ft.lb. of recoil with an old nitro powder, and two or three less with a more modern explosive, does that justify the former amount being considered "excessively great," and the latter being described as "absolutely no recoil"?

The results of our own experience, however, as evidenced by records of trials that we have published, lead to the conclusion that the recoil with Schultze really is greater than it was three or four seasons ago—though we cannot say it is any higher now than it was last year. But this greater recoil we regard as a necessary consequence of the increased velocity shown by this powder. And that there has been such an increase is demonstrated by the fact that the standard of comparison which we have adopted for trials (viz., 1160 ft.sec. in a range of 10 yards, which is equivalent to a muzzle velocity of about 1220 ft.sec.) is produced by a smaller charge than it was several years since; so that while some powders have needed rather more than their nominal charge to bring them up to our standard, Schultze has required several grains less to bring it down to that level. The increase of velocity will probably account for several correspondents saying that this powder has never shot better, if so well as at present; and probably the writers are men who take a firm grip of their guns, or who eschew very light weapons. But the effect of an increase or decrease of velocity on the recoil of the gun should not be overlooked by those who do not adopt this course; for if, with one powder, the shot leaves the barrel with 10 per cent. less velocity, the diminution of recoil will be about 20 per cent. Accordingly, when powders have been sent to us for trial, and we have tested them with charges that produced our standard velocity, the recoil and the stress in the barrel have occasionally been raised beyond what the makers liked, and complaints have been made that we used more powder than they prescribed. But if we had not done so, the penetration would not have been up to the mark; though this might not have been apparent to readers of the report. We may add, however, that we do not think this increase of velocity and recoil is solely due to the makers of the powder. It is no doubt quicker in ignition than it was several years ago; but the strength of caps has also increased, and last, not least, the stoutness of the paper cases, which give greater resistance in the turnover, and thus add to the explosive force of the powder, thereby increasing both velocity and recoil.

Another point which deserves consideration is the fact that all kinds of powder will perform differently when they are loaded in different cartridge cases, with differences in caps, size of wads, amount of turnover, and so on. A marked example of this occurred not long ago in our own experience, with one of the concentrated powders which has recently been recommended by some correspondents as not having defects alleged by others to appertain to Schultze. We had tested the powder last year, and found that it gave very good and regular results when loaded in the manner described in our report of the trial. In the present year some cartridges loaded with the same powder, but in different cases and with different wads, were sent to us to be tried, and we tested them under very similar conditions to those of last year—except as regards the cases, caps, and wads, and that the 1896 cartridges were loaded by ourselves, while those of 1897 were sent to us already loaded. The two lots were fired out of

the same barrel of the same gun, and the difference of results will be seen by the following comparative table:

VELOCITIES (mean of 10 yards range).

	Highest Round.	Lowest Round.	Variation.
1896 cartridges.....	1181 ft.sec.	1123 ft.sec.	53 ft.sec.
1897 "	1124 "	935 "	189 "

The average velocity of ten rounds with the first lot was 1156 f.s., but the average of six rounds of the second lot was only 1019 f.s.; yet the variation with the latter was nearly four times as great as with the former.

RECOIL RECORDS.

	Highest Round.	Lowest Round.	Variation.
1896 cartridges	26·9 ft.lb.	25·0 ft.lb.	7 per cent.
1897 "	23·7 "	17·8 "	25 "

The pattern, too, with the 1897 cartridges varied nearly twice as much as with those of the previous year. So that if the records of the recent trial had been published without any explanation of the causes of difference, it might not unnaturally have been supposed that there was a great deterioration in the quality of the powder; whereas, in fact, we have no doubt that the powder was equally good in the two lots of cartridges, and that the differences of result were solely due to the change of cartridge cases, wads, and method of loading.

With black powders similar changes would be of comparatively small importance; but all the nitro-compounds are more or less influenced by such alterations of circumstances, and some condensed powders rather more than less. Hence the caution one so frequently sees with recommendations of these new powders, that cartridges should be obtained direct from the makers of the powder, or from certain specified loaders. This may be a very good arrangement where the business is small, but where it is so immense as with some powders, it is by no means an easy task to initiate; yet, if it could be carried into effect, it would doubtless save a great deal of heartburning on the part of the manufacturers as well as on that of the users of the explosives; for nobody can have so great an interest in perfecting every point of detail—whether relative to the quantity and quality of the detonating composition in the cap, the form of the cartridge case, the size and material of the wads, the amount of pressure in loading, and the extent of the turn-over—as the makers of the powder, who naturally desire that their product should give the best possible results.

All these apparently small matters of detail have an important bearing upon the effects produced by the combustion of the powder; and they are, for the most part, carefully considered by the manufacturers of explosives, although it by no means follows that they receive equal consideration from the loaders of them. Where gunmakers have a number of small orders for cartridges loaded with many different powders, it is hardly to be expected that all will follow out the various points of detail likely to produce the best effect with each: some are more likely to adopt a general system which they think may produce a tolerably satisfactory result without giving themselves an excessive amount of trouble; and then, if that result is not equally satisfactory to the user of the cartridges, it is by no means improbable that the blame will be thrown upon the powder, instead of on the manner of loading.

That this is no imaginary supposition is evident from the numberless experiments which have been carried out by ourselves and others, and the frequency with which what might be supposed to be well-known cardinal principles are departed from by loaders of cartridges. The makers of the powders may know what will best suit their product, and issue instructions accordingly; but it by no means follows that those instructions are carried out. We have seen instances where powder has been so tightly rammed as to compact the grains into an almost solid block, despite instructions that the pressure should be only sufficient to fairly seat the wad; and then a complaint has been made that the powder was too weak to kill anything. Yet, on the powder being taken out of the cartridge, crumbled up into grains again, and then reloaded in proper fashion, it has shot admirably well.

We have given above a brief comparative table of results obtained from two sets of cartridges, loaded with the same condensed powder, but in different cases. Now we will give a somewhat similar comparison of results that were obtained with another powder; and these details were furnished, not by anyone adverse to that explosive, but by its maker, Mr R. W. S. Griffith, the superintendent of the Schultze Company's works, who delivered a lecture on the patterns of guns before the Gunmakers' Association. [A full report of this lecture is reprinted at pp. 238 to 248.] In the course of that lecture Mr. Griffith described, not only how to load the powder, but "how not to do it;" and we select a few instances to show what wide differences of effect were produced by alterations in the wads, the amount of turnover, and so on. The charges of powder and shot are the same throughout, and so are the cases and caps, the only difference being in the nature of the loading, as stated beneath the following table:

Loading.	Pressure in chamber. Tons.	Time in barrel. Sec.	Muzzle velocity. Ft.sec.	Recoil.
A.....	2·71	·0056	1230	26·0
B.....	3·77	·0048	1294	30·6
C.....	2·18	·0060	926	20·1
D	2·13	·0067	1198	25·0
E.....	3·03	·0054	1205	26·6

NATURE OF LOADING.

A.—42grs. Schultze, with 1¼oz. No. 6 shot; wads on powder, "Field" 11½ card, then ⅜in. felt, and thin card, with a thick card over the shot.

B.—Same charge as before, but (instead of 11½ "Field" card, felt, and thin card) four tight-fitting hard black-edged wads were substituted.

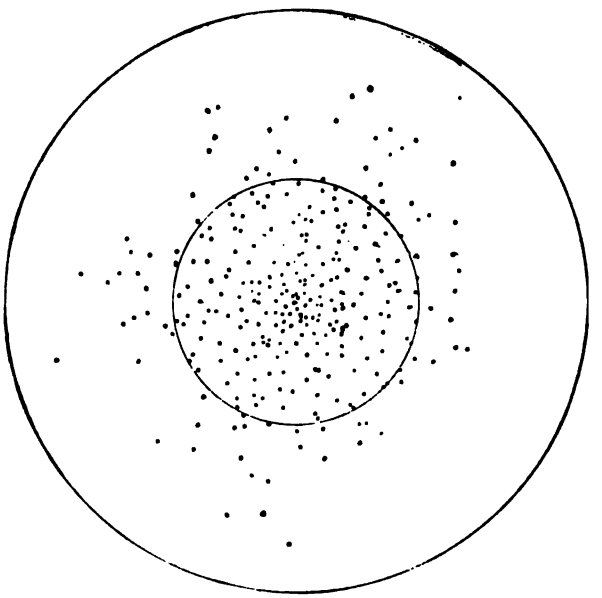
C.—Same charge as before, but loose wads throughout.

D.—Same as A., except that the turnover was very light.

E.—Same as A., except that the turnover was very heavy.

The differences of pressure, velocity, and recoil produced by the change in the wads and the amount of turnover are very noticeable; and we may add that the patterns were often as irregular as the other results. For example, we give illustrations of two patterns made by exactly the same charge of powder and shot, but differing in the wads. The patterns were both made by the choked barrel of the same gun; but in the first the cartridge was loaded with tight wads, as described above by the letter A; and in the second the wads were loose, as stated in the line marked C. Similar differences, more or less, will be found with every nitro explosive.

In pattern A, where the wads were moderately tight, there were 215 pellets in the inner circle of 30in. diameter, and 86 within the outer ring of 6ft. diameter; while the remaining four pellets of the charge were outside the 6ft. circle.

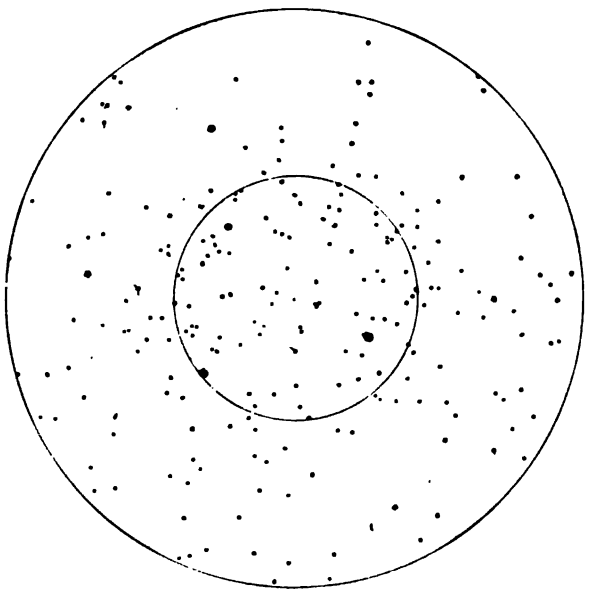


LOADED BY SYSTEM A.

In the other example (C), where wads were very loose, the pattern was as shown in the illustration overleaf—there being only 108 pellets in the 30in. circle, with 142 in the outer ring, and 54 outside the 6ft. circle.

The lecturer said, of this method of loose wadding: "It is entirely fatal to good shooting; the powder gases get past the wads into the shot, and the pattern is not only spoiled, but the penetration injured very considerably. It is a fruitful source of balling" Instances of partial balling of the shot may be seen in the illustration.

Several weeks ago we requested some of our correspondents, who were complaining of defects in the Schultze powder, to send us a few of their cartridges. It was curious that the complaints were of a very opposite character, some saying that the powder was so strong that it kicked violently, and others that it was miserably weak. Such conflicting results seemed to us much more likely to proceed from the loading or the cartridge cases than from irregularity in the powder



LOADED BY SYSTEM C.

itself. Only one of those whom we requested to send us cartridges complied with our wishes; but several other gentlemen have kindly sent samples unasked for, and we will now proceed to state the results of our experience in testing them. One wrote as follows:

Dear Sir,—Referring to your invitation to send you Schultze cartridges, I enclose four out of a batch of 300, recently purchased, which have been most unsatisfactory. Although I have used less than 100 of them, at least three have gone off with a "fizz," and dropped the shot a few yards from the muzzle of the gun—of course causing no recoil of any kind. I shall be very glad if you can tell me whether there is anything amiss with the powder. In the case of one which I opened it appeared to be caked.

W. A. DURNFORD.

We opened one of the four cartridges, and observed nothing wrong in the loading. The other three cartridges we tested by crusher-gauge, and there was not the slightest probability that these would have dropped the shot within a few yards of the gun, as the pressures were unusually high, two being 3·80 tons each, and the other 4·00 tons. Whether these pressures were due to strong caps we are unable to say; but if some other of the caps were very weak, or if the powder were so much compressed as to be caked, that may perhaps have accounted for cartridges going off with a "fizz," which these certainly did not do.

Another gentleman, who had not taken any part in the previous correspondence (Sir William G. Pearce, Bart.), sent us a few of his 12-bore cartridges for trial. They performed somewhat erratically, and we were inclined to think there was something wrong either in the caps or the loading. We accordingly requested the sender to oblige us with a larger supply, and he forwarded thirty, which enabled us to carry out much more exhaustive experiments. In order to ascertain whether the caps—which were of medium size—varied materially, we opened twenty of the cartridges, took out the charges (they were very regular in weight), and then tested the strength of the caps in the cases that had been emptied. The method adopted for this purpose was the same as was described at length, with an illustration of the apparatus, in the *Field* of Sept. 12, 1896, in an article entitled "The Ignition of Gunpowders." [Here reprinted at pp. 211 to 215.] The results of this test went to show that there was considerable variation in the strength of the respective caps, as the energy of the highest was equivalent to 20·97 foot-pounds, whereas that of the lowest of the same batch amounted only to 8·63 ft.lb., as will be seen by the following records of the twenty caps. We put the highest and lowest in *italic* figures for facility of reference:

TRIAL OF TWENTY CAPS (MEDIUM SIZE).

Velocity.		Energy.		Velocity.		Energy.	
438	ft.sec.	19·96	ft.lb.	401	ft.sec.	16·73	ft.lb.
396	"	15·50	"	344	"	12·31	"
366	"	13·93	"	293	"	8·93	"
320	"	10·65	"	367	"	14·01	"
320	"	10·65	"	347	"	12·52	"
396	"	15·50	"	396	"	15·50	"
367	"	14·01	"	*288*	"	*8·63*	"
359	"	13·41	"	360	"	13·53	"
369	"	14·16	"	*449*	"	*20·97*	"
355	"	13·11	"	344	"	12·31	"

Average Energy, 13·81 ft.lb.; Highest round, 20·97; Lowest, 8·63.

Five of the same batch of cartridges, which had not been opened, were then tried for velocity and recoil, and five others were tested for pressure in the chamber of the gun. Of course, we do not know what was the strength of the caps in these unopened cartridges, but the results came out as follows:

CARTRIDGES CONTAINING MEDIUM CAPS.

	Average.	Highest.	Lowest.
Velocity	1152 ft.sec.	1210 ft.sec.	1099 ft.sec.
Recoil	29·0 ft.lb.	31·9 ft.lb.	25·0 ft.lb.
Pressure	2·20 tons	2·40 tons	1·96 tons.

We also tested, in a similar manner, the charges which had been taken out of the cases above mentioned, and transferred into other cases by the same maker, but of a different colour, and containing caps of a smaller size. We likewise tested separately the strength of the caps in twenty new unloaded cases of the same brand. These small caps exhibited considerably less propulsive energy than the larger ones previously alluded to, as will be seen by reference to the next table:

TRIAL OF TWENTY CAPS (SMALL SIZE).

Velocity.		Energy.		Velocity.		Energy.	
267	ft.sec.	7·41	ft.lb.	288	ft.sec.	8·63	ft.lb.
254	"	6·71	"	*194*	"	*3·91*	"
232	"	5·60	"	293	"	8·93	"
236	"	5·79	"	248	"	6·40	"
251	"	6·55	"	296	"	9·11	"
297	"	9·17	"	254	"	6·71	"
245	"	6·24	"	200	"	4·16	"
318	"	*10·52*	"	256	"	6·82	"
235	"	5·74	"	281	"	8·21	"
248	"	6·40	"	271	"	7·64	"

Average Energy, 7·08 ft.lb.; Highest round, 10·52; Lowest, 3·91.

But, notwithstanding the apparently smaller amount of force in the lesser caps when used without any powder, the velocity, recoil, and pressures were higher when loaded cartridges were used, as will be seen by a comparison of the following figures with the corresponding ones that have been previously given:

CARTRIDGES CONTAINING SMALL CAPS.

	Average.	Highest.	Lowest.
Velocity	1214 ft.sec.	1277 ft.sec.	1167 ft.sec.
Recoil	29·9 ft.lb.	31·9 ft.lb.	27·5 ft.lb.
Pressure	3·06 tons	4·34 tons	2·34 tons.

These apparently conflicting results may doubtless be explained by the composition in the medium caps being somewhat different in chemical constituents from that contained in the small primers; and that the small quantity of one composition produced on the powder a greater exciting effect than resulted from the use of a larger quantity of the other composition.

Among the gentlemen whom we requested, a few weeks ago, to send us samples of the cartridges of which they complained was Mr Faunce de Laune. Those which he forwarded we tested by crusher-gauge, and found the pressures high; but there were not sufficient for carrying out other experiments, and we requested a larger supply. The cartridges were of 16-bore, and contained 38grs. of Schultze powder with 1oz. of No. 6 shot; the wads over the powder were a thick card, ⅜ inch felt, and thin card, with a thick card over the shot. We tried six for velocity and recoil, and seven for pressure in the chamber of the gun. The results were as follows:

	Average.	Highest Round.	Lowest Round.
Velocity	1222 ft.sec.	1277 ft.sec.	1176 ft.sec.
Recoil	24·0 ft.lb.	25·0 ft.lb.	23·5 ft.lb.
Pressure	3·66 tons	4·48 tons	3·26 tons

Here the velocities are exceedingly high—the average being fully 60 f.s. above our usual standard, so that the average muzzle velocity probably reached 1800 f.s., while some of the rounds were considerably higher. The pressures, too, were very high as a rule, and one round reached 4·48 tons. We think it probable, from the variations in velocity and pressure, that the strength of the caps must have varied considerably; but we were unable to test this, as our apparatus for the purpose is only fitted for 12-bore cases.

The recoil, as recorded above, is very low; but that is due to the fact that (not knowing the weight of Mr Faunce de Laune's 16-bore) we did not alter our recoil apparatus, which ordinarily is arranged for a 7lb. gun. But with a lighter gun the recoil would of course be higher—say about 28 ft.lb. with one of 6lb., and more for those of lighter weight. With Schultze powder, as made for the last year or two, 38grs. is rather a full charge for 16-bores. In experiments that we carried out about eighteen months ago, six 16-bores reached our standard of velocity with an average of 36grs., and the recoil with that charge was rather over 26 ft.lb. with a 6lb. gun, and nearly 28 ft.lb. with one of 5½lb. [see Summary, p. 158 *ante*]; but then the powder charge was 2grs. less than in Mr Faunce de Laune's cartridges, so velocities were lower, and pressures less.

As regards the amount of smoke, respecting which a good deal has been said, we did not notice any marked difference from what there has been seen in the same powder hitherto. We should not be surprised, however, if more smoke were noticeable in instances where caps were weak, and so failed to cause a perfect combustion of the powder, especially on days when the atmosphere is very humid and without wind. There is another matter, too, that has to be taken into consideration, and that is the fact that formerly the comparison lay between 32grs. of black powder and about half that weight of the older nitros; and now the comparison is made between 42grs. of the older nitros and about two-thirds that weight of condensed powders. The black powders contain about 60 per cent. of solid residue, the older nitros about 18 to 20 per cent., and the concentrated powders about half the percentage of the bulky ones; and so low a percentage is much less perceptible in the small quantities which are employed in a charge.

Some correspondents seem to think that powder manufacturers should inform their customers when they are issuing a batch of powder of unusual strength. The writers evidently know very little of the amount of pains which the manufacturers take for the express purpose of eliminating (as far as it is possible to do so by human agency) all risk of the powders being issued of strength different from the prescribed standard. We were very much impressed with this during a visit which we made to the Schultze Company's works a year or two ago, when all the various processes were explained to us, and the precautions taken were fully described. It may perhaps surprise many of our readers to learn that a "batch" of their powder represents a quantity sufficient to load five millions or more of ordinary cartridges; and it may also interest them if we give a few details received from the superintendent of the works. We were informed how, at every stage of the various processes, the products were examined and tested by chemists and other officials, and the various lots carefully mixed, so as to produce uniformity of blend and equality of strength, until it reached the stage when it could really be called a gunpowder; and thenceforward we may repeat some recent words of the manager:—"We are making about a ton a day. Every day's work is mixed perfectly as one; tested as to its strength; given a distinct mark, and stored in the magazine till the end of the week. The six groups which have been made during the six days are then mixed together to form one weekly batch; it receives a distinct letter, and is tested in all particulars. Our rule is that these batches remain in the magazines for three months before being sent out for sale. At the end of three months these batches are tested again, and the results are compared with those obtained when the batch was first mixed and put aside. If the results confirm the former ones, and are perfectly satisfactory, this batch is then mixed with other batches that are also of sufficient age, and have passed the tests to form a mixture—which mixture receives a distinct number. These mixtures are never less than 30,000lb. in weight, and this would load five million cartridges; and many are larger. When the mixtures are complete, the powder is tested in every known method (and this means a great deal); and if it then exactly conforms to our standard it is passed for issue. At three distinct stages it has a complete testing, before being passed on."

We think we have said sufficient to show that batches of gunpowder are not thrown into the market haphazard. And although all works cannot be on the same scale of magnitude, we have no doubt that other manufacturers likewise do their utmost, in a similar way, to produce reliable explosives for the use of the public.

EFFECT OF CHANGE OF POWDERS.

(*Field*, Sept. 1, 1894; Vol. 84, p. 340.)

SIR,—I should be very much obliged if you or some of your readers, would kindly inform me what is the difference of velocity for 40 yards at which 42grs. of Schultze powder, as compared with 3drs. of the best black powder, would propel 1⅛oz. of No. 6 shot out of a 12-bore cyclinder gun. I take it that the difference in the velocity is so slight that for all practical purposes of aiming it is hardly appreciable. R. G. W.

[We quite agree with R. G. W. that the difference would be inappreciable. The time for 40 yards is very short, and a change in the variety of powder would not produce so much effect as a change in the size of shot. In some experiments we recently carried out the mean velocities recorded, in the 40 yards range, with one black powder and three nitro-compounds, were as follows: Curtis and Harvey's No. 4 treble strong (3drs.), 821 feet per second, which, for a distance of 40 yards, is equivalent to a time of ·1462sec.; with E.C. (42grs.), the velocity was 825 f.s., or time ·1454sec.; with Schultze (42grs.), 832 f.s. velocity, or time 1442ses.; and with Amberite (42grs.), 843 f.s. velocity, or time ·1426sec. Consequently, between the two extremes there was a difference of 21 f.s. in velocity, or ·0036sec. in time—that is to say, less than 4-thousandths of a second. With respect to variations in size of shot there are much greater differences of time, as will be seen by reference to the following extract, which we quote from "An Illustrated Treatise on the Art of Shooting, by Charles Lancaster, 151, New Bond-street, W." After giving some particulars relative to the velocities recorded by two kinds of black powder and one nitro-compound, the chapter on "Times and Velocities" goes on to say:

"These chronograph records represent, not the velocity of the shot at its exit from the muzzle, nor that with which the pellets strike the target, but the mean velocity, or average speed for the entire distance of 40 yards; and, consequently, the velocities can be easily reconverted into times by the simple process of dividing the length of range (120ft.) by the velocity in feet per second. . . . The times here given are results obtained by Mr. Griffith, in experiments with Schultze powder, the charge being 42grs. (equivalent to 3drs. of black powder), with 1⅛oz. of shot. Four sizes of shot are here given, at ranges extending from 20 yards to 60 yards, and the variations of time were as follows:

Range.	No. 2 shot. Sec.	No. 4 shot. Sec.	No. 6 shot. Sec.	No. 8 shot. Sec.
20 yards	·0569	·0594	·0596	·0624
30 ,,	·0913	·0949	·0975	·1038
40 ,,	·1304	·1377	·1429	·1528
50 ,,	·1755	·1883	·1979	·2179
60 ,,	·2300	·2548	·2779	·3220

It will be observed that (the charge of powder being the same throughout) the time increases as the shot lessens in size; and that the differences are much more marked in long ranges than in short ones. . . . . Up to 30 yards there is practically little difference between the various sizes of shot; for a few inches more or less are not of much importance with a charge of shot that has a spread of several feet. When, however, distances beyond 30 yards are traversed, the falling off in speed of the smaller pellets becomes considerable; and the farther they go the more they suffer."

The time given above, as relating to No. 6 shot and Schultze, in a 40 yards range, is ·1429sec., which corresponds with 839 ft.sec. mean velocity; whereas the velocity quoted in the *Field* of Aug. 18, 1894, relating to a trial which we carried out with the same kind of powder, same quantity of shot, and same length of range, but with a different gun, gave a mean velocity of 832 f.s.; so that here the difference of velocity is 7 f.s., equivalent in time to little more than one-thousandth of a second in the two sets of experiments, taken about seven years apart, by different persons, with different guns. In a previous page, Mr. Lancaster quotes the velocity of C. & H. No. 4, 3drs. and 1⅛oz. shot, with same distance, as 827 f.s.; or only 6 f.s. difference from our trial mentioned above. These velocities, we may add, were all taken with choked barrels; but in the *Field* of April 9, 1887, Mr. Griffith gave the results of an elaborate series of experiments, carried out with cylinder barrel as well as chokebore, both loaded with 42grs. of Schultze and 1⅛oz. of No. 6 shot. The average pattern made in the 30in. circle at 40 yards by the choke barrel was 283; with the cylinder barrel of the same gun the pattern was 130. The mean velocity for 40 yards with the choked barrel was 839 f.s., as above stated; with the cylinder, tried under exactly the same conditions, the mean velocity for the 40 yards was 813 f.s., or 26 f.s. less than that of the chokebore.—ED.]

A TARGET TRIAL OF WILDFOWL GUNS.

(*Field*, Nov. 27, 1897; Vol. 90, p. 836.)

SIR,—As so little is known of the performances of punt guns and of heavy shoulder-guns at a really large target, I send you a *résumé* of some experiments therewith which I have lately carried out.

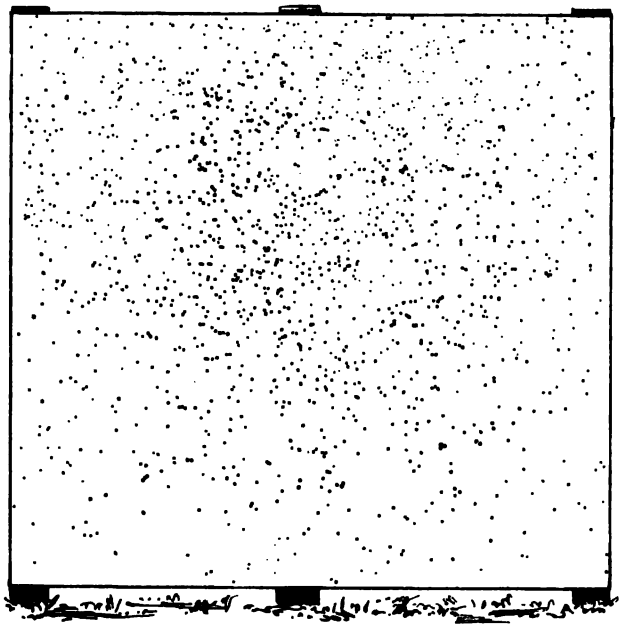
My object in firing the guns at so large a target as one of 12ft. square was to enable me to note thereon the entire spread of each charge in the case of the shoulder-guns, and to ascertain—and thus create a standard for—the shooting of punt guns at a target large enough to do full justice to their capabilities.

The patterns of the shoulder-guns are interesting, as they show what happens to their shot-pellets in that *terra incognita* outside the orthodox (and, in my opinion, much too small for a proper test) gun-maker's 30in. circle.

GUN No. I. (BENTLEY AND PLAYFAIR, Birmingham, 1880).

Breechloading single-barrel punt gun, 2in. bore. Cylinder. Converted in 1897 from a 1⅞in. muzzle-loader to a 2in. breechloader by Messrs Holland, 98, New Bond-street, London.

Present weight, 175lb.; original weight, 180lb. Length of barrel, 9ft.



TARGET-PLAN A. (1592 pellets.) Scale, ½in.=1ft.

Charge of powder, 6¼oz. Colonel Hawker's grain for the first three shots of the series, and 7oz. for the last three shots.

Charge of shot, 2lb., B.; 80 pellets = 1oz.

Pellets of shot in each cartridge case, 2560.

Target, ¼in sheet iron, 12ft. by 12ft.

Six shots—at 70 yards from gun-muzzle to centre of target. Pellets on the target in the six shots, 1580, 1708, 1592, 1747, 1654, 1715.

PENETRATION.—In the six shots 84 pellets struck the Pettitt's paper pad which was suspended 1in. in front of the centre of the target; 28 pellets passed through, or broke, all 44 sheets of the pad; and 18 pellets, 41–43 sheets

REMARKS.—Weather (three days)—dry and calm. Aim was taken at a mark placed 1ft. above the centre of the target. The pellet marks very evenly distributed, but a trifle high in two of the shots, including the one reproduced above. The penetration, as always occurs with punt guns, much superior to that of the shoulder guns, though the latter were used with the same size of shot, and at considerably shorter distances. I have fired many hundred shots from this gun at wildfowl when it was a muzzle-loader, and I then considered it the cleanest and longest killer I ever saw.

The third of this series of shots (1592 pellets) is shown above, in target-plan A.

GUN No. I. (BENTLEY and PLAYFAIR, Birmingham, 1880).

Breechloading single-barrel punt gun, 2in. bore. Cylinder. Converted in 1897 from a 1⅞in. muzzle-loader to a 2in. breechloader by Messrs Holland, 98, New Bond-street, London.

Present weight 175lb.; original weight, 180lb. Length of barrel 9ft.

Charge of powder, 6¼oz. Col. Hawker's grain for the first two shots of the series, and 6½oz. for the last shot.

Charge of shot, 2lb., SSSG.; 18 pellets = 1oz.

Pellets of shot counted into each cartridge case, 576.

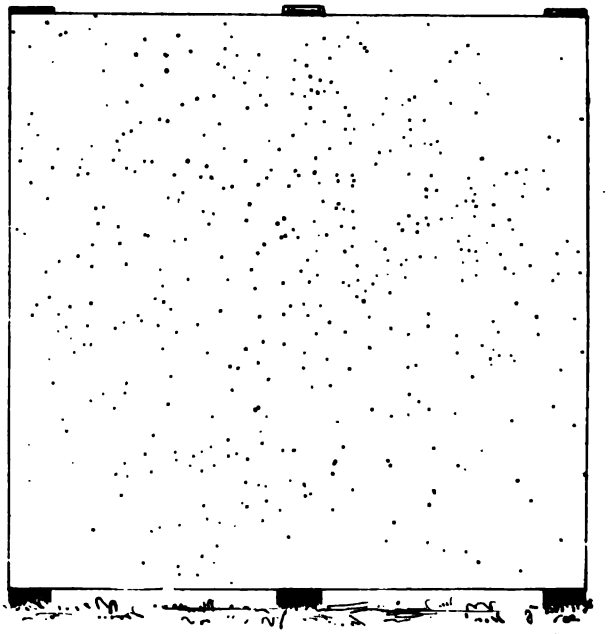
Target, ¼in. sheet iron, 12ft. by 12ft.

Three shots—at 90 yards from gun-muzzle to centre of target.

Pellets on the target in the three shots, 448, 471, 490.

PENETRATION.—Eight Pettitt's pads placed in four detached couples (one pad behind the other, thus giving a thickness of 88 sheets) were suspended against four parts of the target near its centre. In the three shots 32 pellets struck the four sets of doubled pads; 7 pellets passed through, or broke, 62 sheets of the pads; and 18 pellets, 55-61 sheets.

REMARKS.—Weather (two days)—dry, with fresh wind from the left



TARGET-PLAN B. (471 pellets.) Scale, ½in.=1ft.

across the range. Aim was taken at a mark placed 14in. above and 6in. to the left of the centre of the target.

Considering the small number of shot pellets in the charge and the distance the gun was fired at, this is a very fine performance in every respect. These large shot pellets made dents in the iron target to a depth of half their circumference, and in some instances cracked the material.

The second of this series of shots (471 pellets) is shown above, in target-plan B.

GUN No. II. (MESSRS HOLLAND, 98, New Bond-street, London).

Breechloading single-barrel punt gun, 1½in. bore. Medium choke.

Weight, 100lb.; length of barrel, 8ft. 6in.

Charge of powder, 3oz. Colonel Hawker's large grain for the first three shots of the series, and 3½oz. for the last three shots.

Charge of shot, 1lb. B., 80 pellets = 1oz.

Pellets of shot in each cartridge case, 1280.

Target, ¼in. sheet iron, 12ft. by 12ft.

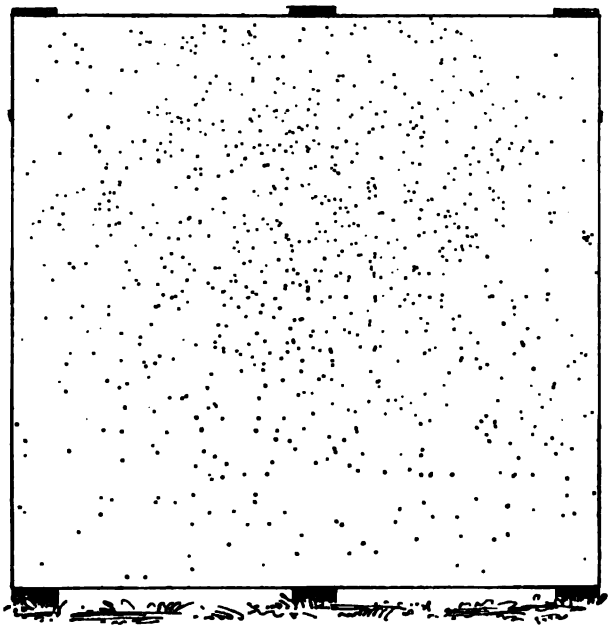
Six shots—at 70 yards from gun-muzzle to centre of target.

Pellets on the target in the six shots, 851, 869, 807, 878, 920, 887.

PENETRATION.—In the six shots 53 pellets struck the Pettitt's paper pad that was suspended 1in. in front of centre of target; 12

pellets passed through, or broke, all 44 sheets of the pad; and 9 pellets, 41-43 sheets.

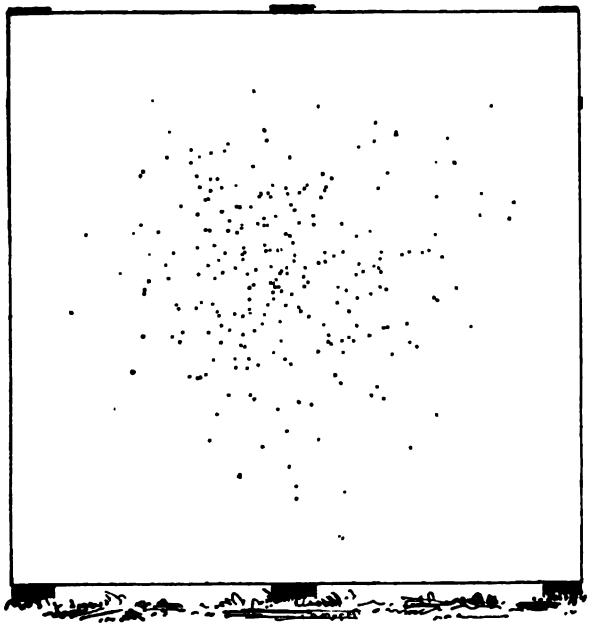
REMARKS.—Weather (two days)—dry, with strong wind from the left across the range. Aim was taken at a mark placed 8in. to the left,



TARGET-PLAN C. (869 pellets.) Scale, ½in.=1ft.

and 1ft. above the centre of the target. The pellet marks very evenly distributed over the target in all six shots. The penetration, as in the 2in. gun, much above that of the shoulder guns.

The second of this series of shots (869 pellets) is shown above, in target-plan C.



TARGET-PLAN D. (260 pellets.) Scale, ½in.=1ft.

GUN No. III. (BLAND AND SONS, 430, Strand, London).

Breechloading single-barrel 4-bore. Medium choke.
Weight, 14½lb.
Charge of powder, 10drs. Curtis and Harvey's diamond grain No. 6.
Charge of shot, 3⅜oz. B., 80 pellets=1oz.
Pellets of shot counted into each cartridge case, 270.
Target, ⅛in. sheet iron, 12ft. by 12ft.

Six shots—at 60 yards from gun-muzzle to centre of target.

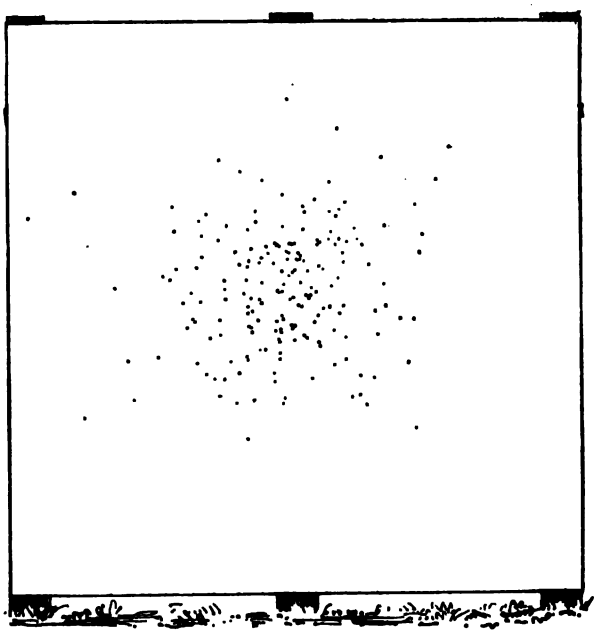
Pellets on 12ft. by 12ft. target in the six shots, 265, 264, 269, 268, 260, 258.

Pellets inside a circle of 4ft. diameter, in the six shots, 137, 141, 148, 132, 129, 126.

PENETRATION.—In the six shots, 53 pellets struck the Pettitt's paper pad, which was suspended 1in. in front of the centre of the target; 15 pellets passed through, or broke, 33-34 sheets; 8 pellets, 31-32 sheets; 17 pellets, 29-30 sheets; and 4 pellets, 27-28 sheets.

REMARKS.—Weather—dry and calm. Aim was taken at a mark placed one foot above the centre of the target. A fine pattern, and a most suitable one for groups of wildfowl, as the charge is not (as too often occurs) clustered together in the middle of the target, which means killing one or two of the central birds of a company twice over with a treble dose of lead, whilst the birds on either side of them are missed or merely wounded!

The fifth of this series of shots (260 pellets) is shown in the previous column, in target-plan D.



TARGET-PLAN E. (190 pellets.) Scale, ½in.=1ft.

GUN No. IV. (BLAND AND SONS, 430, Strand, London).

Breechloading double-barrel 8-bore. Medium choke.
Weight, 13lb.
Charge of powder, 6½drs. Curtis and Harvey's diamond grain No. 6.
Charge of shot, 2⅝oz. B., 80 pellets=1oz.
Pellets of shot counted into each cartridge case, 190.
Target, ⅛in. sheet iron, 12ft. by 12ft.

Six shots—at 50 yards from gun-muzzle to centre of target.

Pellets on the 12ft. by 12ft. target, in the six shots, 186, 187, 183, 185, 190, 189.

Pellets inside a circle of 4ft. diameter, in the six shots, 128, 133, 131, 122, 129, 136.

PENETRATION.—In the six shots 48 pellets struck the Pettitt's pad which was suspended 1in. in front of centre of target; 14 pellets passed through, or broke, 35-36 sheets; 5 pellets, 33-34 sheets; 16 pellets, 31-32 sheets; and 5 pellets, 27-30 sheets.

REMARKS.—Weather—dry with fresh wind from the left across the range. Aim was taken at a mark placed 8in. above and 4in. to the

left of the centre of the target. This gun, like the 4-bore, made excellent patterns, and just the ones for small groups of wildfowl. Though an 8-bore has not, of course, the killing power of a 4-bore, yet it is a far handier weapon to use both ashore and afloat.

The fifth of this series of shots (190 pellets) is shown in target-plan E, in the preceding page.

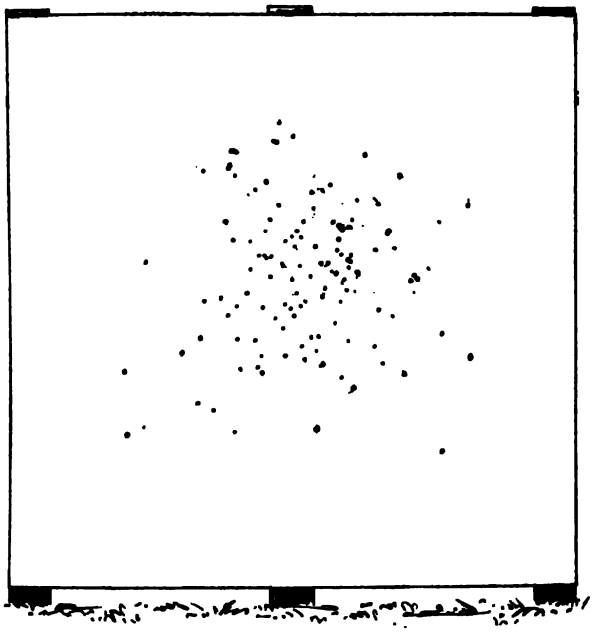
GUN No. V. (BLAND AND SONS, 430, Strand, London).

Breech-loading double-barrel 10-bore. Medium choke.
Weight, 9lb.
Charge of powder, 4drs. Curtis and Harvey's diamond grain No. 6.
Charge of shot, 1¼oz. B; 80 pellets=1oz.
Pellets of shot counted into each cartridge case, 120.
Target, ⅛in. sheet iron, 12ft. by 12ft.

Six shots—at 50 yards from gun-muzzle to centre of target.

Pellets on the 12ft. by 12ft. target in the six shots, 116, 118, 114, 115, 112, 114.

Pellets inside a circle of 4ft. diameter, in the six shots, 85, 81, 84, 80, 78, 82.



TARGET-PLAN F. (115 pellets.) Scale, ½in.=1ft.

PENETRATION.—In the six shots 31 pellets struck the Pettitt's paper pad, which was suspended 1in. in front of the centre of the target; 13 pellets passed through, or broke, 36-37 sheets, 6 pellets 34-35 sheets, 3 pellets 33 sheets, and 3 pellets 30-32 sheets.

REMARKS.—Weather—dry, with fresh wind from gun to target. Aim was taken at a mark placed 4in. above the centre of the target. A rather open but a regular pattern. This gun acted exceedingly well with a smaller sized shot (104 pellets=1oz.), and at a distance of 45 yards—conditions more suitable to, and a fairer test of, the gun. At the same time it may be noted that one or two B shot would be capable of killing a mallard or wigeon. A gun of this description is well adapted for bringing down large single birds as wild-geese, or for firing at a few fowl grouped together.

The fourth of this series of shots (115 pellets) is shown above, in target-plan F.

GUN No. VI.

Breechloading double barrel 12-bore. Full choke.
Weight, 7lb.
Charge of powder, 45grs. Schultze.
Charge of shot, 1⅛oz. No. 6; 270=1oz.
Pellets of shot counted into each cartridge, 304.
Target, ⅛in. sheet iron, 12ft. by 12ft.

Six shots—at 40 yards from gun-muzzle to centre of target.

Pellets on the target in the six shots, 295, 298, 301, 296, 302, 294.

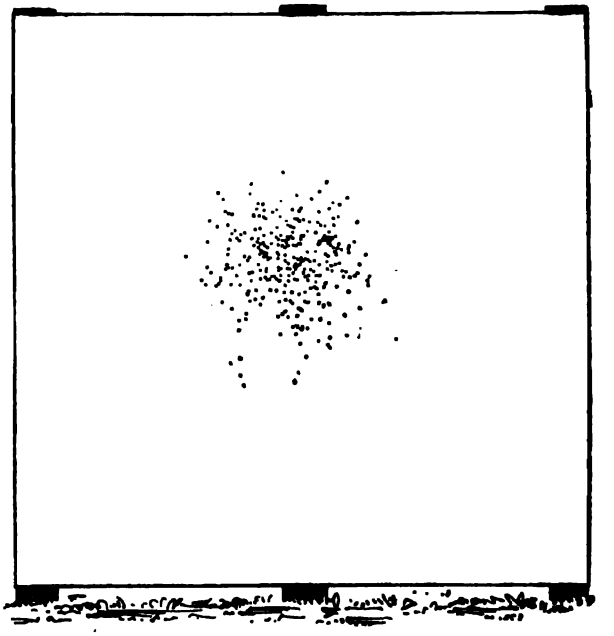
Pellets inside a circle of 30in. diameter, in the six shots, 218, 220, 212, 223, 211, 227, 216.

PENETRATION.—A large proportion of the pellets that struck the Pettitt's pad, suspended 1in. in front of centre of target, passed through, or broke, from 20-22 sheets; a small number 24-25 sheets.

REMARKS.—Weather—dry and calm. Only 38 pellets (out of the 1824 fired in the series) went wide of the target. A splendid gun for killing single wildfowl at distance of 40 to 45 yards as well as for game birds when they rise wild in front of a shooter as he walks them up. The worst possible one, however, for driven game, such as pheasants and partridges, at ordinary ranges, as in the above pattern only 12 pellets show outside a circle of 4ft. in diameter!

The fourth of this series of shots (296 pellets) is shown in target-plan G, given below.

NOTE.—It will be observed that I have not usually given the target plans of the best patterns of any series so far as numbers of pellet are concerned. I have generally preferred to reproduce the patterns



TARGET-PLAN G. (296 pellets.) Scale, ½in.=1ft.

that show the greatest regularity of spread. It also sometimes happened that after I had spent many hours in wafering, counting, and then photographing two or three of the first patterns made by a gun, that the gun subsequently excelled these in merit, though I had not anticipated it could do so, nor had I the time, perhaps, to prepare for reproduction one of these slightly better performances.

The following comments on these trials may be of interest to your wild-fowling readers. The punt guns were fired from a specially constructed gun-carriage on high wheels, and which was fitted with a rope-breeching to take up recoil. These guns were strapped to the framework of the carriage so that their barrels could not "jump," and throughout any series of shots the guns were aimed, I may say, within an inch of the same spot on the target every time.

The various distances at which the guns were fired were carefully measured, and marked by stakes driven into the soil. The guns were placed parallel to the ground at the same height as the centre of the target. In the case of the large charges of B shot that were fired from the punt guns the individual pellets were not counted, for it would have occupied days to do so. These charges were, however, accurately weighed, and each charge had 8oz. of its contents taken out at random and the pellets numbered to make sure the shot that composed the charge was of proper size, *i.e.*, 80 pellets = 1oz.

Previous to a pattern being photographed a small black wafer was stuck over each of its pellet marks, as this not only facilitated a perfectly correct count, but also caused the pattern to photograph distinctly.

The wafers (the lawyer's "this is my act and deed" sort) were ½in. in diameter, and of these I used nearly 10,000.

By dipping the finger into a saucer of thick whitewash (as was employed to coat the target with between each shot) and then dabbing the liquid over a shot-mark on the target a wafer could be securely attached, though not so firmly that it could not easily be removed, and in many instances used again.

It occupied four men, two on step ladders and two on the ground, two hours to cover with a wafer each pellet mark in any of the thickest patterns, such as A, and it took me about an hour to pick rapidly off the target, with a penknife, the wafers of any such pattern and count them by the hundred at a time.

The number of pellets in a pattern was afterwards corroborated by pricking with a needle (fixed in a penholder) each shot-mark on the face of the enlarged photographic print that represented the pattern in question. Then to dot with a finely pointed lead pencil, and in this way count the pricks where they showed through on the white back of the photograph, was an easy matter.

The Pettitt's paper pads were the regulation ones of 9½in. by 10in., and each consisted of forty-four sheets of hard, thick, brown paper, closely pressed together.

Before the pads were used they were kept for some days at a temperature of 70°, for, if damp, I find they are uncertain for testing the penetration of a gun.

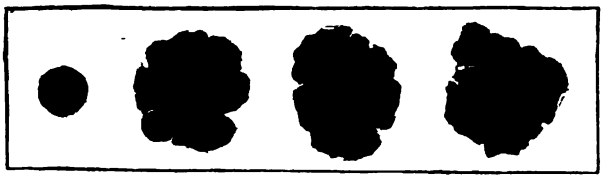
When shot-pellets, as often happened, struck a pad and did not penetrate all its sheets, hence, of course, failing to make a mark on the target, all such partial holes (after noting penetration) were punched clean through with a saddler's strap punch. The pad was then held in its original position against the front of the target, and a fine pencil passed through each hole as a means of marking on the target the spots the pellets would have impressed if the latter had not been intercepted by the suspended pad.

THE SHOULDER-GUNS I discharged from the shoulder with their barrels on a rest, and no joke it is firing in "cold blood" a dozen shots in a day from a single-barrelled 4-bore.

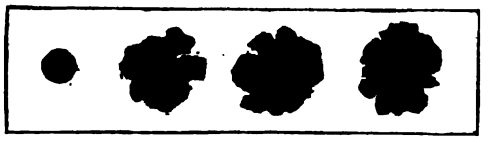
It will be seen that Messrs Bland and Sons' guns shot most admirably, particularly the 4-bore and the 8-bore.

The performance of Messrs Holland's 2in. punt gun, with SSSG, was far beyond what I had hitherto imagined any gun could accomplish.

I send for reproduction in outline a few of the shot pellets picked up near the target.



SSSG (18=1oz.) Before and after being fired (at 90 yards).



B (80=1oz.) Before and after being fired at 70 yards).

The examples of SSSG above shown were fired from the 2in. punt gun at 90 yards, and the B pellets from the same gun at 70 yards. The 1½in. puntgun also flattened its pellets to an equal extent, often as thin as paper. By laying large sheets of paper at the foot of the target, I was able to gather for comparison some of the pellets of the charge after each shot was fired.

As in shoulder-guns, so in the large punt guns, a considerable proportion of the shot pellets are greatly damaged in the barrel, being jammed or knocked out of their spherical shape, when the gun is fired, into one that is all angles and small flat surfaces.

To test this I fired one of the punt guns into a bag of sawdust, and, though there was no sign of flattening by impact, at least one-third of the pellets extracted from the sawdust were misshapen in contour.

Another thing worth comment is that all the thick felt wads used with the punt guns were found, on picking them up, to have their edges hollowed out as if by a small gouge, their form being somewhat like that of a pulley wheel that takes a rope round its recessed rim.

I imagine this is caused by the explosion of the powder, and the subsequent resistance of such a heavy mass of shot, so compressing the softer interior of the wad between its surfaces that the felt round its edges is continually squeezed out against the interior of the barrel during transit, and is thus cut off by friction. On leaving the barrel the wad would then expand again as a whole, and its edges would naturally show a cavity where the material had been forced out and rubbed off.

I fired two shots from the 1½in. punt gun with a nitro-compound, and charges recommended to me for such a purpose by the manufacturers. In both instances the recoil was so excessive that the gun-carriage was nearly upset, and the patterns on the target were most unsatisfactory. Fearing an accident, I discontinued any further experiments of this nature.

There is little doubt that a confined column of air some 8ft. long by 1½in. diameter offers too great a resistance for a quick-burning compound to dislodge without undue strain on the barrel and action of the gun.

Though I have in these notes described only the trials of guns suitable for wildfowl, I will add that I also shot some high-class cylinder and slightly choked game-guns at the 12ft. by 12ft. target. These latter, at 40 yards, gave the usual patterns of from 120-140 pellets inside the 30in. circle, but what surprised me was their killing regularity of spread within a 4ft. circle; the open spaces and bunched groups of pellets shown by the full choke (target-plan G) being absent. I also found that the central pellets of the cylinders and slightly choked guns in all cases (excepting that of a 20-bore) penetrated quite as many sheets of the Pettitt's pads as did the fully choked barrels.

RALPH PAYNE-GALLWEY.

Thirkleby Park, Thirsk, October, 1897.

[The experiments carried out by Sir Ralph Payne-Gallwey are very interesting, and, so far as we know, are unique of their kind. The performance of the punt gun of 2 inch bore, when loaded with SSSG shot, was remarkable; and the differences of result, as compared with patterns made by the same gun with shot of a smaller size, will probably be a surprise to many of our readers. Of the B pellets there are 80 to the ounce, and of the SSSG there are but 18; hence a pellet of the latter size weighs more than four times as much as one of the former. The first illustration in Sir R. Payne-Gallwey's letter shows a pattern made by 2lb. of B shot propelled by 6½ ounces (*i.e.*, 100 drams) of powder, at a distance of 70 yards from the gun. The total number of pellets in the charge was 2560, of which 1592 were placed within the 12ft. square; hence about 20oz. of B shot struck the target, and the remaining 12oz., or 38 per cent. of the entire charge, were scattered outside. On the other hand, when SSSG shot was used, in the same gun, with the same weight of powder and shot as before, about 26oz. struck the target and only 6oz. or 18 per cent. missed it, despite the fact that the target was 20 yards farther away from the gun.

To compare great things with small, one might liken this punt-gun, its weight, charges, &c., as having about the same comparative proportion as a shoulder-gun of 5½lb. weight, loaded with 3½drs. of powder and 1oz. of shot, and fired sometimes with pellets of No. 2 size at a distance of 45 yards, and at others with No. 8 at 35 yards—the target being one-fourth the area of that used for the punt-gun. It would probably surprise many persons if they found that, with equal charges by weight, the No. 2 shot placed 82 per cent. of its pellets on the target at the longer range, whereas the No. 8 placed but 62 per cent. within the same space at the shorter distance; for there is a not uncommon belief that the larger pellets would be likely to scatter most. Nevertheless, evidence is forthcoming to show the contrary, as some experiments, on a smaller scale, with a 12-bore, were carried out nearly twenty years ago, which gave somewhat similar results to those stated above. Thus Mr R. W. S. Griffith found that with 3drs. of powder and 1oz. of shot the breadth of pattern was greater with No. 8 than it was with No. 2; and when the powder was increased to 3½drs., it affected the small shot more than that of larger size—the spread of pattern being 5 inches with No. 2 at 5 yards from

the muzzle of the gun, and 7 inches with No. 8 at the same distance. Some years afterwards we carried out a series of experiments to ascertain the differences of spread with the shot-charges from choked and cylinder barrels, and we found that the width of the pattern increased pretty regularly with the increase of distance. Thus, supposing the pattern to be a foot in breadth at 10yds. from the muzzle of the gun, it would be near about 2ft. broad at 20yds., 3ft. at 30yds., and so on. Hence we conclude that if the 1oz. charge of No. 2 had a breadth of 5in. at 5yds., it might be expected to be about 40in. broad at 40yds., and if a charge of No. 8 were 7in. wide at 5yds. it would probably be about 56in. wide at 40yds. If, then, such be the effect of spread in a charge of 1oz., fired from a 12-bore, we may expect a corresponding increase in a 32oz. charge, fired from a tube that has nearly eight times the area of the 12-bore barrel, with a shot-charge about four or five times the length of that in the 12-bore cartridge. Supposing, then, that a 32oz. charge of SSSG shot had a spread of 20in. at 10yds., and a similar charge of B shot had a spread of 30in. at a like distance, the latter would, at 70yds., have a much wider spread than the former would have at 90yds. Of course, the measurements here given are purely hypothetical; but we have assumed them in order to set forth what seems to us to be a possible explanation of the difference in spread of the two charges of shot that are equal in weight but different in size of pellets.

As evidencing how greatly some isolated pellets are driven away from the main charge, reference may be made to the last pattern given by Sir R. Payne-Gallwey, in which the whole body of 1½oz. No. 6 shot appears to be placed in the centre of the target. Nevertheless there are eight pellets missing, showing how widely they must have diverged to miss so large a target.—ED.]

NITRO POWDERS IN WILDFOWL GUNS.

8-BORE AND 4-BORE.

(*Field*, Aug. 27, 1892; Vol. 80, p. 331.)

ON several occasions we have been requested to try the effect of nitro powders in the large shoulder-guns that are used for wildfowl shooting. One recent correspondent wrote to us the following letter:

Sir,—I have often mooted the question, "Why don't we use the nitro powders in our big shoulder-guns?" Most gunmakers to whom I have named the matter say they do not recommend it; and Mr. Greener, in his able work, "The Modern Shot Gun," seems to hold a similar opinion.

In my game guns, and in my heavy 12-bore, carrying 4drs. and 1¼oz., I never use anything but nitro powder, as black invariably gives me gun-headache if I have many shots. But when I take my 8-bore after duck I always use black; because, until I have some reliable data as to the safety and efficiency of large charges of nitro powder, I prefer not to try any experiments in that line. Consequently, I remain a martyr to gun-headache.

You, sir, generally go right to the root of these questions, and cut the Gordian knot of argument by scientific demonstration. If you could, therefore, see your way to institute a test of large guns (say 8 and 4 bores), with nitro *versus* black powder, for recoil, pattern, penetration, and barrel pressure, I am sure it would be of great interest and value to the wildfowling world at large. J. P. T.

The first thing, as it seemed to us, was to ascertain the amount of strain given in the barrel with the respective powders, so as to obtain some notion of how far they might be considered safe or dangerous in comparison with the official tests to which guns are submitted in the proof-houses. We know that nitro powders such as are ordinarily used in 12-bores and smaller weapons have also been employed in large wildfowl guns without doing them any injury. But it is notorious that some guns are capable of withstanding again and again much greater strains than they are likely to encounter in the proof-house, whereas others collapse under considerably smaller strains if often repeated; and it will not do to assume, because one 4-bore or 8-bore has been used with a particular powder or particular charge, that every gun of the same category would be equally safe under similar circumstances.

We first tested with the crusher-gauge the strain exhibited by the definitive proof-charges of powder and shot for the respective bores, as laid down in the official Scale of Proof. These consist of double the quantity of powder ordinarily adopted as the "service charge" of the gun, and an increase of one-third in the weight of shot; but No. 6 pellets are used in the proof of shot guns of all guages, and the proof powder for large bores is the same as for small-bores. Afterwards we tested sporting charges of black and nitro powders. Where the latter are stated in drams, it means that the quantity used was the same as would fill a black-powder measure for that number of drams. The method adopted in loading these charges, whether nitro or black, was to use the ordinary "Field" loading. In one instance, as afterwards mentioned, two "Field" wads were used with S.R. powder, in order to give a better development of force. Eley's ordinary green cases were used throughout. The pressures exhibited by the respective powders will be seen by reference to the following table. Six rounds were fired of each, and we have arranged the individual rounds, not in the order they were fired, but with the lowest pressure first and the highest last, so as to facilitate comparison.

8-BORE—CRUSHER-GAUGE RECORDS.

Charges.	Pressure in tons per square inch.						Averages.
Proof powder, 12drs., and 2½oz. No. 6 shot	6·82	6·86	6·86	6·86	6·87	6·87 =	6·86 tons.
C. & H. No. 7, 6drs., and 2oz. No. 2 shot	2·79	2·88	3·00	3·06	3·20	3·24 =	3·03 ,,
Schultze, 6drs., and 2oz. No. 2 shot	5·54	5·72	5·87	5·92	5·96	6·02 =	5·84 ,,
E.C., 6drs., and 2oz. No. 2 shot	5·63	5·70	5·90	5·92	5·98	6·04 =	5·86 ,,
S.S., 6drs., and 2oz. No. 2 shot	5·74	5·92	5·96	5·96	6·18	6·75 =	6·08 ,,
S.R., 7drs., and 2oz. No. 2 shot	2·70	2·83	2·96	3·04	3·16	3·43 =	3·02 ,,
S.R., same charge, but two "Field" wads	4·63	4·68	4·74	4·80	4·80	4·82 =	4·74 ,,
S.S. and S.R., 3drs. of each, and 2oz. shot	5·18	5·29	5·46	5·54	5·92	6·00 =	5·56 ,,
Schultze, powder reduced to 5drs., shot as before	4·30	4·36	4·85	5·31	5·36	5·39 =	4·92 ,,

On comparing these results, it will be observed that the six rounds with proof powder gave very even records—more so than any of the sporting powders. The pressures exhibited by No. 7 black (a powder commonly used in large wildfowl guns) were very low; but with the three nitros manufactured mainly for 12-bores (Schultze, E.C., and S.S.) the increase in pressure was considerable as compared with the black explosive. The difference between these three nitro powders was not very great, and many 8-bore guns are doubtless strong enough to withstand the charges here employed; but we could not advise their use generally, as the average pressures run too close to those of the proof records; and the fact cannot be overlooked that the difference between highest and lowest is usually more strongly marked with nitros than in the case of black powders. It may also be remarked that, although one kind of nitro powder may chance to exhibit a little more or a little less pressure than another in a trial made to-day, it by no means follows that exactly the same results will be repeated if other samples of these powders undergo a similar trial to-morrow; so it is desirable to allow a somewhat larger margin for safety than would be required in the case of black powder giving an equal average strain. And, unless we had some definite knowledge of the strength of a gun, we should not care to use it with cartridges which we knew to exceed two-thirds the strain of the proof-charge. The latter is fired but once; the service charge is repeated continuously.

With the S.R. powder (which is made for use in Martini-Henry and other rifles) the pressures exhibited were very low, although an extra dram was used; but the combustion of this powder is so slow that there was a decided hangfire—its only drawback. With a view to remedy this, we introduced a second "Field" wad, which had some beneficial effect, although it did not completely remove the hangfire. We also tried the use of a priming of the same company's S.S. powder, to give S.R. a fillip at starting; but if sufficient S.S. be used to overcome the hangfire, it also causes too much pressure; and we therefore prefer the two "Field" wads; for, although they also cause an increase in the strain, it is not to so dangerous an extent.

The charges which we thought it best to adopt for use in the 8-bore gun, we afterwards tried with the chronograph for velocity, and at the target for pattern in a 6ft. circle at 80 yards. The velocity was taken for 5 yards from the muzzle of the gun, and consequently is the mean speed for that distance; the actual muzzle velocity (which cannot be exactly ascertained) might possibly be about 2 per cent. higher. The gun used in these trials was a single-barrel 8-bore, weight 9¾lb., length of barrel 36in., made by Messrs. J. and W. Tolley. It shot well with both powders; but the nitro gave rather the higher results, especially as regards pattern. Three rounds were fired for velocity, and five for pattern. The records (arranged in order for comparison) were as follows:

VELOCITY OF SHOT WITH 8-BORE GUN.

	Feet per second.			Averages.
C. & H. No. 7, 6drs., and 2oz. No. 2 shot	1181	1190	1194 =	1188 ft.sec.
S. R., 7drs., two "Field" wads, and 2oz. shot	1194	1194	1197 =	1195 ,,

PATTERN AT 80 YARDS (6ft. circle).

C. & H. No. 7, 6drs., and 2oz. No. 2 shot	68	83	89	103	103 =	89 pellets.
S. R., 7drs., two "Field" wads, and 2oz. shot	96	118	138	148	169 =	134 ,,

So far as regards the velocity, the results with 6drs. black and 7drs. nitro were nearly the same; but, as is commonly the case with nitro powders, there was a considerable increase in the number of pellets placed on the target.

The experiments with the 4-bore were very similar in character to those above-mentioned, but we did not try quite so many variations in the loading. It will be observed, at starting, that in the test with the proof-charge (although 6drs. more powder were used, and an additional ounce of shot) the strain exhibited was almost identical with that of the 8-bore; and with Schultze, E.C., and S.S. there is some little decrease of strain as compared with the 8-bore.

4-Bore—Crusher-Gauge Records.

Charges.	Pressure in tons per square inch.						Averages.
Proof powder, 12drs., and 4oz. of No. 6 shot	6·80	6·82	6·84	6·86	6·93	7·03	= 6·88 tons.
C. & H. No. 7, 9drs., and 3oz. of BB shot	3·20	3·39	3·54	3·54	3·57	3·64	= 3·48 ,,
Schultze, 9drs., and 3oz. of BB shot	4·90	4·90	4·90	5·18	5·18	5·27	= 5·05 ,,
E.C., 9drs., and 3oz. of BB shot	4·97	4·97	5.00	5·41	5·59	5·83	= 5·29 ,,
S.S., 9drs., and 3oz. of BB shot	5·18	5·18	5·22	5·25	6.30	6·79	= 5·65 ,,
S.R., 10½drs., and 3oz. of BB shot	2.65	2·74	3·12	3·64	3·67	3·81	= 3·27 ,,
S.S. and S.R., 4½drs. of each, and 3oz. of BB shot	5·52	5·92	6·12	6·14	6·18	6·30	= 6·03 ,,

It will be again observed that, although there was an increase of 1½ drs. in the charge of S.R. powder, the pressure was very low in comparison with the other nitros; but when S.S. was used as a primer, to get rid of the hang-fire, the pressure was nearly doub'ed, although the extra quantity of 1½drs. was omitted.

Velocities and pattern were also taken with a 4-bore, which was a single duck gun weighing 14½lb., with 37½in. barrel, and was also made by Messrs. J. and H. Tolley. The records were as follows:

Velocity of Shot with 4-Bore Gun.

	Feet per second.		Averages.
C. & H. No. 7, 9drs., and 3oz. of BB shot	1080	1092	1142 = 1105 ft.sec.
S.R., 10½drs., and 3oz. of BB shot	1089	1116	1142 = 1116 ,,

Pattern at 100 Yards (6ft. circle).

C. & H. No. 7, 9drs., and 3oz. of BB shot	42	44	48	48	52 = 47 pellets.
S.R., 10½drs., and 3oz. of BB shot	52	66	68	69	70 = 65 ,,

It may be remarked that, although there was an ounce more shot than was used in the 8-bore, the number of pellets in the charge was much less; and the fact that the target was at a greater distance must also be considered in regard to the reduced pattern.

With respect to recoil, we may state that, as felt upon the shoulder, it was much less with the nitro than with the black powder; but we are unable to give any exact records as taken with the recoil-gauge, for our machine was not constructed for use with such extreme charges, and it was quickly crippled when an attempt was made to employ it for this purpose.

FURTHER EXPERIMENTS WITH NITRO POWDERS IN WILDFOWL GUNS.

8-Bore.

(*Field*, April 21, 1894; Vol. 83, p. 554.)

Many questions have been asked in our columns, from time to time, relative to the suitability of nitro powders for guns used in wildfowl shooting; and nearly two years ago (see article above, p. 262) we published particulars of experiments which we had then carried out with black and nitro powders in 4-bore and 8-bore guns. The results were not altogether so satisfactory as could be wished, and we have recently been induced to try some further experiments, so as to include other powders which have since been brought before the public, though not manufactured expressly for use in wildfowl guns.

As a standard of comparison we have, as before, used a black powder which is celebrated for its excellent qualities when employed in guns of large bore, viz., Curtis and Harvey's No. 7 grain. We have also tried several well-known nitro powders ordinarily employed for game shooting, such as Schultze, E.C., and S.S., besides others which, though specially made for rifles, were thought likely to be also found suitable for use in smoothbores of wide gauge; and we have likewise tested the Amberite powder issued by the Clyde Mills Company, and several varieties of German explosives manufactured by the Walsrode Company. Of the rifle powders, the S.R. and '450 Rifleite, made by the Smokeless Powder Company, and four kinds (K.P. 2, K. 2, K. 3, and M H.) made by the Walsrode Company, were, owing to hang-fires, found unsuitable for the work in hand, and consequently were not passed through the whole of the tests. The sample of S.S. was also found unsuitable, but for a very different reason—the strain in the barrel being too great for safety. This is a curious example of the necessity of caution when applying an explosive to a purpose different from that for which it has been manufactured. The very same sample of powder, when tested in a 12-bore with the ordinary charge for that gauge, gave a rather low pressure; nevertheless, when it was used in the 8-bore, with the corresponding increase of powder and shot, the pressure exhibited exceeded that shown by the proof-charge; and the violence of the explosion was demonstrated likewise by the badness of the pattern, the scattered pellets on the target being low in number and very irregular. Five other powders (including a "leaflet" or flake powder made by the Walsrode Company) were tried, in an 8-bore gun, for pattern at 60 yards and 80 yards, also for velocity, amount of recoil, and strain in the barrel as shown by the crusher-gauge.

The 8-bore used on the present occasion was a double gun, weighing 13lb. 2oz.; but only the left barrel was employed, in order that the variations occurring in the course of the shooting might not be supposed to arise from any difference in the boring of the two barrels. The cartridges were Eley's green cases, 3½in. long; and the loading comprised, first, a grey cloth wad, then a half-inch felt, a thin card between the felt and the shot, and another grey cloth wad over the shot. Several other kinds of wadding were tried in preliminary experiments, but that above stated gave by far the best results, and was accordingly adopted throughout the general trial. Two ounces of No. 2 shot (121 pellets to the ounce) was used with all the powders; and the charge of black powder was 6drs. (*i.e.*, 164grs.); but the weight of the nitro powders varied in accordance with the recommendations of the makers of the respective explosives. For the Walsrode leaflet powder special cases had to be used; and, like those mentioned above, they were made by Messrs. Eley, but they differed in the caps, which were stronger than those used for the rest of the powders.

The patterns made, at 60 yards and 80 yards, by the five varieties of powder hereafter named, were as follows:

Patterns made by 2oz. of No. 2 shot in 40in. circle, at 60 yards range.

										Average.
C. & H. No. 7, 6drs.	104	81	90	79	88	93	100	91	101	80 = 91
Schultze, 84grs.	108	120	116	86	99	102	120	118	62	112 = 108
E.C., 84grs.	108	109	111	115	90	104	91	103	95	99 = 103
Amberite, 60grs.	92	93	109	113	93	108	100	88	110	98 = 100
Walsrode leaflet, 50grs.	83	97	65	70	80	73	100	83	91	98 = 84

Patterns made by 2oz. of No. 2 shot in 40in. circle, at 80 yards range.

										Average.
C. & H. No. 7, 6drs.	45	60	61	39	58	40	35	42	55	50 = 48
Schultze, 84grs.	47	53	50	41	44	60	55	47	58	60 = 53
E.C., 84grs.	48	55	37	44	59	49	47	58	39	59 = 50
Amberite, 60grs.	40	36	58	42	50	55	40	59	35	38 = 45
Walsrode leaflet, 50grs.	46	53	33	40	58	50	35	42	36	49 = 44

The patterns made in the 40in. circle at 80 yards, when compared with those made at 60 yards, run tolerably close to what might be expected to result from the difference in length of range. Theoretically it might be supposed that the spread of the shot-charge would widen out in proportion to the square of the increase in distance, and consequently that the number of pellets placed within the circle would, at 80 yards, be near about one half of the number placed in the same space at 60 yards. The greatest departure from this proportion occurred with the powder that imparted the least velocity to the shot. It may here be mentioned that the area of the 40in. circle is very nearly equal to 9 sq. ft.; hence, on dividing the above-mentioned patterns by 9, the average number of pellets per square foot will be approximately ascertained.

The velocity recorded by chronograph (*i.e.*, the mean velocity for a distance of 40 yards from the muzzle of the gun), with the charge above stated (viz., 2oz. of No. 2 shot) was as follows:

Mean Velocity of shot in 40 yards range.

	Feet per second.					Average.
C. & H. No. 7, 6drs.	900	898	905	913	897	= 903 ft.sec.
Schultze, 84grs.	964	960	940	980	980	= 965 ,,
E.C., 84grs.	965	1001	968	979	968	= 984 ,,
Amberite, 60grs.	805	820	853	814	831	= 825 ,,
Walsrode leaflet, 50grs.	958	939	951	955	951	= 951 ,,

The velocities here given are lower than those stated in the report of our previous trial, as these are the mean velocities of a 40 yards range, whereas the former ones were those of only 5 yards from the muzzle. The longer range may afford a better idea of the ultimate striking force or penetration, as shot-charges not unfrequently scatter considerably, and thereby fall off greatly in speed.

We add, however, for the sake of comparison, records of 5 yards velocity exhibited by the same five powders. The averages respectively made were as follows: C. & H. No. 7, 1184; Schultze, 1245; E.C., 1277; Amberite, 1138; and Walsrode leaflet, 1182ft. sec.

The amount of recoil, taken simultaneously with the above-mentioned mean velocities of 40 yards, was as follows:

RECOIL, taken at the same time as the Mean Velocity.

	Foot-pounds.				Average.
C. & H. No. 7, 6drs.	40·0	39·6	38·0	40·0	39·0 = 39·3 ft. lb.
Schultze, 84grs.	38·6	36·8	37·0	40·6	40·0 = 38·6 ,,
E.C., 84grs.	41·4	41·6	40·4	40·8	39·0 = 40·6 ,,
Amberite, 60grs.	23·0	23·2	26·0	23·2	23·6 = 23·8 ,,
Walsrode leaflet, 50grs.	30·0	28·0	29·6	29·0	30·0 = 29·3 ,,

The amount of strain in the barrel, with the respective powders, as taken by crusher-gauge, was as follows:

8-BORE CRUSHER-GAUGE RECORDS.

	Tons per sq. inch.				Averages.
C. & H. No. 7, 6drs.	2·26	2·29	2·21	2·26	2·25 = 2·25 tons.
Schultze, 84grs.	3·10	3·74	3·92	3·52	4·02 = 3·66 ,,
E.C., 84grs.	3·44	2·67	3·12	2·97	2·79 = 3·00 ,,
Amberite, 60grs.	1·92	2·55	2·55	2·34	2·24 = 2·32 ,,
Walsrode leaflet, 50grs.	3·18	3·08	3·30	3·44	3·16 = 3·23 ,,

These results were obtained with the same charge as before (2oz. of No. 2 shot, and the quantity of powder stated). But, besides the above, the pressure exhibited by a larger charge of the black powder (viz., 6½drs. of C. & H. No. 7, with 2½oz. of No. 2 shot) was also ascertained; and with this increased charge the pressure was 2¾ tons per sq. inch, instead of 2¼ tons as recorded with the normal charge.

We may here state briefly that the amount of strain recorded by the official proof-charge for 8-bores (viz., 12drs. of proof powder and 2⅝oz. of No. 6 shot) averaged 5·25 tons. And, as some people may not improbably use, in 8-bore guns, black powder of smaller grain than No. 7, we also give the pressures exhibited by No. 6 and No. 4 grain—the charge being the same as in the case of No. 7, viz., 6drs. of powder with 2oz. of No. 2 shot. The pressures thus recorded were, with C. & H. No. 6, 3·87 tons, and with C. & H. No. 4, 4·34 tons per sq. inch.

In connection with the above records of strain in the barrel, it is requisite to allude to the fact that the figures which are here given are lower than those which were stated at the time of our previous trial of wildfowl guns. In carrying out recently a long series of crusher-gauge experiments for the purpose of framing an extended scale, to include the very high pressures developed in small-bore rifles loaded with certain modern explosives, it appeared desirable to modify, in some degree, the former method of procedure. Instead of invariably employing lead cylinders of equal dimensions as the "crushers" for strains differing widely in amount, we came to the conclusion that more accurate records were obtainable by varying the size and metal of the crusher, according to the increase of pressure. Consequently we now make use of small lead cylinders only for the low pressures, whereas lead cylinders of larger diameter are used for higher pressures, and copper cylinders for those pressures which are extremely high; and three scales, based on the results of numerous experiments, have been framed for service with the respective cylinders. These scales overlap one another to some extent, and so provide a certain amount of check upon the records that are taken. Thus, pressures made upon the small leads, and interpreted by means of figures at the end of Scale I., may, if thought desirable, be repeated on the larger leads, and checked by figures at the commencement of Scale II.; and a similar course may be adopted with the lead cylinders of Scale II. and the copper cylinders of Scale III.

The general results of these trials may be summarised as follows:

	Pattern 60 yards.	Pattern 80 yards.	Velocity. (40 yds.)	Recoil.	Crusher-gauge.
C. & H. No. 7, 6drs.	91	48	908 ft.sec.	39·3 ft.lb.	2·25 tons.
,, No. 6, 6drs.	—	—	—	—	3·87 ,,
,, No. 4, 6drs.	—	—	—	—	4·34 ,,
Proof powder, 12drs.	—	—	—	—	5·25 ,,
Schultze, 84grs.	108	52	965 ,,	38·6 ,,	3·66 ,,
E.C., 84grs.	108	50	984 ,,	40·6 ,,	3·00 ,,
Amberite, 60grs.	100	45	835 ,,	23·8 ,,	2·32 ,,
Walsrode, 50grs.	84	44	951 ,,	29·3 ,,	3·23 ,,

It will be observed that the pressure exhibited in the barrel by No. 7 black powder was the lowest of the whole series, and was less than one-half of that shown by the official proof-charge; but that No. 4 and No. 6 black gave a higher pressure than either of the four nitro powders here reported on.

FURTHER 8-BORE TRIALS.

(*Field*, May 12, 1894; Vol. 83, p. 659.)

IN an article of April 21, 1894 (here given at p. 263), we published a report of a trial of various nitro powders in an 8-bore wildfowl gun. In the following week it was pointed out by "Sheldrake" that the records of velocity and recoil made by Amberite powder were so low as to indicate that the charge then used was inadequate to propel 2oz. of shot with efficiency. We were quite of the same opinion, and accordingly promised to try the gun again with an increased charge of Amberite. At the same time we took the opportunity of testing a new variety of Schultze powder, which reached us after the previous trial had been carried out. Like the Schultze powder previously issued, this new variety was not expressly made for wildfowl guns, but is intended for use in game guns of 12 bore and smaller gauge; and its chief difference from the ordinary Schultze lies in the fact that the grain of the new powder has been hardened, so as to render it less subject to atmospheric influences, such as heat and damp.

We have now carried out a supplementary trial of these two powders; and we find that Amberite may be safely used in much larger charges than we were previously advised to adopt. Of course, with the increased quantity of powder, and the consequent addition to the velocity of the shot, there is also a considerable increase in the recoil of the gun and the amount of strain in the barrel; but these are by no means excessive, as compared with the extra work done. With respect to the new variety of Schultze, we think it desirable to somewhat diminish the charge of powder, as compared with the older kind; for we found that, when 84grs. of the hard-grain Schultze were used, there was an undesirable increase of strain in the barrel; and, as not unfrequently happens when there is an addition to the propulsive force, it was accompanied by a greater scattering of the pellets, and a consequent falling off in the pattern. So we found that better results were obtained by the use of 80grs. of the hardened-grain Schultze, instead of 84grs.

For facility of comparison, we reproduce the figures given in our previous article; and, in so doing, we also rearrange them to some extent. In the former report, the records were printed in the same order as that in which the rounds were fired; consequently it was not easy to compare the degrees of variation which occurred from time to time. On the present occasion we place the records in numerical order, so that the reader may see at a glance, as he looks along each line, how far the highest and lowest of the records depart from the general average. We need hardly say that the smaller the amount of variation in a gun's performance, from shot to shot, the more satisfactory, as a rule, are the results; and if one kind of powder gives a very close pattern in some rounds and a very open one in others, it can hardly be relied on to the same extent as another powder which shows fair regularity of pattern every time it is fired. Especially, too, is regularity a matter of importance when it relates to strain in the barrel.

The powder used for proof purposes is generally very regular in the pressure it exhibits; and other black powders are usually more regular than nitro-compounds. We here give the pressures recorded by five rounds each of the several black and nitro powders which we have recently tested. In the proof charge, the shot required by the regulations is No. 6 soft; in the other instances, the shot used was No. 2 chilled.

CRUSHER-GAUGE RECORDS OF PRESSURE WITH 8-BORE GUN.

	Tons per square inch.					Averages.
BLACK POWDERS:						
Proof Powder, 12drs. and 2⅝oz.	5·15	5.17	5·21	5·23	5·50	= 5·25
C. & H. No. 7, 6drs. and 2oz.	2·21	2·35	2·26	2·26	2·29	= 2·25
,, No. 6, ,, ,,	3·78	3·84	3·86	3·92	3·96	= 3·87
,, No. 4, ,, ,,	4·28	4·30	4·32	4·38	4·40	= 4·34
NITRO POWDERS:						
Schultze, Old, 84grs. and 2oz.	3·10	3·52	3·74	3·92	4·02	= 3·66
,, Hard, 84grs. ,,	3·50	3·90	4·06	4·14	4·32	= 3·99
,, ,, 80grs. ,,	3·76	3·80	3·84	3·85	3·88	= 3·83
E.C., 84grs. ,,	2·67	2·79	2·97	3·12	3·44	= 3·00
Amberite, 60grs. ,,	1·92	2·24	2·34	2·55	2·55	= 2·32
,, 84grs. ,,	2·76	2·94	3·10	3·26	3·30	= 3·07
Walsrode leaflet, 50grs. ,,	3·08	3·16	3·18	3·30	3·44	= 3·23

It will here be seen that, with equal charges of the old and the new samples of Schultze, the latter exhibited most strain in the barrel;

and a similar thing occurred with 80grs., though not to an equal extent. It will be observed, however, that in the 8-bore with the hard-grain sample there was less variation than with the old powder. With Amberite, the strain was not very high even when the charge was raised to 84grs.; and the variation in pressure with this large charge was not so great as when only 60grs. were used. With both powders, there was a falling off in pattern as the force increased, as will be seen by the following table:

PATTERNS made by 2oz. of No. 2 shot, in 40in. circle, at 60 yards range.

											Average.
C. & H. No. 7, 6drs.	79	80	81	88	90	91	93	100	101	104	= 91
Schultze, Old, 84grs.	62	96	99	102	108	112	116	118	120	120	= 103
,, Hard, 84grs.	69	70	77	79	81	86	88	90	94	96	= 83
,, ,, 80grs.	77	79	88	88	90	96	98	98	101	108	= 92
E.C., 84grs.	90	91	95	99	103	104	108	109	111	115	= 103
Amberite, 60grs.	88	92	93	93	98	100	108	109	110	113	= 100
,, 84grs.	63	80	84	85	88	95	98	100	110	111	= 91
Walsrode leaflet, 50grs.	65	70	73	80	83	83	91	97	98	100	= 84

PATTERNS made by like charges at 80 yards range.

C. & H. No. 7, 6drs.	35	39	40	42	45	50	55	58	60	61	= 48
Schultze, Old, 84grs.	41	44	47	47	50	53	55	58	60	60	= 52
,, Hard, 84grs.	35	36	37	39	40	41	44	50	55	58	= 44
,, ,, 80grs.	38	38	40	44	50	52	53	53	55	59	= 48
E.C., 84grs.	37	39	44	47	48	49	55	58	59	59	= 50
Amberite, 60grs.	35	36	38	40	40	42	50	55	58	59	= 45
,, 84grs.	37	40	41	42	43	47	50	51	53	54	= 46
Walsrode leaflet, 50grs.	33	35	36	40	42	46	49	50	53	58	= 44

The increase of force is especially noticeable in the higher velocity of the shot when it leaves the muzzle; and the hard Schultze shows more regularity in the different rounds than was exhibited by the old powder, as will be seen by reference to the next table:

MEAN VELOCITY for 5 yards range, with 2oz. shot.

	Feet per second.					Averages.
C. & H. No. 7, 6drs.	1180	1182	1185	1186	1190	= 1184 ft.sec.
Schultze, Old, 84grs.	1200	1230	1250	1265	1282	= 1245 ,,
,, Hard, 84grs.	1315	1316	1339	1364	1365	= 1340 ,,
,, ,, 80grs.	1293	1316	1327	1339	1339	= 1323 ,,
E.C., 84grs.	1250	1271	1282	1282	1300	= 1277 ,,
Amberite, 60grs.	1119	1119	1136	1154	1163	= 1138 ,,
,, 84grs.	1200	1210	1250	1271	1293	= 1245 ,,
Walsrode leaflet, 50grs.	1155	1156	1200	1200	1200	= 1182 ,,

It will be observed, however, that there is a considerable reduction in the velocity of the shot before it reaches 40 yards; and the more the shot is scattered, the greater, as a general rule, is the falling off in speed.

MEAN VELOCITY for 40 yards, with RECOIL taken simultaneously.

						Averages.
C. & H. No. 7, 6drs.	Velocity	897	898	900	905	913 = 903 ft.sec.
	Recoil	39·0	39·6	40·0	38·0	40·0 = 39·3 *ft.lb.*
Schultze, Old, 84grs.	Velocity	940	960	964	980	980 = 965 ft.sec.
	Recoil	37·0	38·8	36·6	40·0	40·6 = 38·6 *ft.lb.*
,, Hard, 84grs.	Velocity	1023	1023	1026	1043	1045 = 1032 ft.sec.
	Recoil	39·6	39·8	39·4	39·6	39·8 = 39·6 *ft.lb.*
,, Hard, 80grs.	Velocity	1019	1023	1030	1033	1036 = 1028 ft.sec.
	Recoil	39·0	39·0	39·1	39·8	39·5 = 39·3 *ft.lb.*
E.C., 84grs.	Velocity	965	979	988	988	1001 = 984 ft.sec.
	Recoil	41·4	40·8	39·0	40·4	41·6 = 40·6 *ft.lb.*
Amberite, 60grs.	Velocity	805	814	820	831	853 = 825 ft.sec.
	Recoil	23·0	23·2	23·2	23·6	26·0 = 23·8 *ft.lb.*
,, 84grs.	Velocity	1001	1001	1005	1005	1019 = 1006 ft.sec.
	Recoil	34·0	35·2	36·0	36·0	36·8 = 35·6 *ft.lb.*
Walsrode leaflet, 50grs.	Velocity	939	951	951	955	958 = 951 ft.sec.
	Recoil	28·0	29·6	30·0	29·0	30·0 = 29·3 *ft.lb.*

With the same kind of powder, an increase of recoil is the usual accompaniment of an increase in the speed of the shot, though occasional exceptions occur from time to time. But some powders regularly produce less recoil than others, even though they may impart higher velocity to the shot.

(*Field*, June 9, 1894; Vol. 83, p. 814.)

4-BORE TRIALS.

IN a previous article (page 263) we mentioned that, besides the powders of which we gave full records, we had also, tested seven other varieties—three being of English make (S.S., S.R., and ·450 Rifleite) and four of German manufacture (Walsrode K 2, K 3, K P 2, and M.H), all of which were found unsuited to the work in hand, either through being too slow in combustion, and consequently hanging fire, or else being too quick in combustion, and thereby becoming dangerous, owing to the great amount of strain set up in the barrel. These remarks, however, are not intended to disparage the powders alluded to, but merely to indicate that explosives manufactured for fire-arms of one description are not necessarily suited to arms of a different character.

In our present article we do not go into detail respecting the powders that have been found unsuitable. We merely propose to give information respecting those which appear to be more or less adapted for employment in guns of No. 4 gauge. And with one of these we did not persevere throughout all the tests, as we found that it hung fire so much as to render its use most unsatisfactory.

We first give, for the sake of comparison, records taken by crusher-gauge of the amount of strain set up in the barrel by the regulation proof-charge for 4-bores (viz., 18drs. of proof powder, with 4oz. of No. 6 soft shot), and it will be seen that the average pressure exhibited by this charge amounted to a fraction over 6¼ tons per square inch. The pressures given by the six other powders mentioned below were, with one exception, less than half that of the proof-charge. For facility of comparison we give the records in numerical order, and not in the order of firing the respective rounds.

RECORDS OF PRESSURE TAKEN WITH 4-BORE CRUSHER GAUGE.

	Tons per square inch.						Averages.
Proof powder, 18drs. and 4oz. No. 6 shot	6·00	6·15	6·30	6·30	6·44	6·44	= 6·27 tons.
C. & H. No. 7, 9drs. and 3oz. B.B.	2·58	2·73	2·85	2·85	2·88	2·94	= 2·80 ,,
Schultze, Old, 112grs. and 3oz. B.B.	2·52	3·00	3·12	3·14	3·22	3·72	= 3·12 ,,
Schultze, Hard, 112grs. and 3oz. B.B.	2·88	2·91	2·97	3·04	3·14	3·14	= 3·01 ,,
E.C., 112grs. and 3oz. B.B.	2·46	2·52	2·91	2·97	3·06	3·10	= 2·84 ,,
Amberite, Special, 120grs. and 3oz. B.B.	1·41	1·47	1·53	1·60	1·63	1·63	= 1·54 ,,
Amberite, No. 2, 112grs. and 3oz. B.B.	3·56	3·70	3·72	3·72	3·76	3·76	= 3·73 ,,

It will be observed that one sample of Amberite (a special powder made for use in 4-bores) gave by far the lowest pressure of the whole series, and the other Amberite powder (the ordinary No. 2 variety) gave the highest pressure of the nitro powders; but it was nevertheless 2½ tons below that of the proof-charge. Both these powders, and the hard-grain Schultze likewise, were very regular in their pressures from round to round—surpassing in this respect the No. 7 black powder, which is noted for its regularity. The special Amberite, however, we had subsequently to set aside, in consequence of its hanging fire badly.

The gun used was a single-barrel 4-bore, weighing 17lb., and the cartridges were Eley's green cases, 4in. long. The wadding generally used was grey cloth, with two felts $\frac{5}{16}$in. and $\frac{7}{16}$in. thick respectively, then a card, and a cloth wad over the shot. The best results were given with the two felts between powder and shot; but only one could be used with the 120grs. of special Amberite, as the cartridge case would not hold more. The records for mean velocity (40 yards) and amount of recoil were taken simultaneously, and are given in the following table:

MEAN VELOCITY in 40 yards, with RECOIL (taken simultaneously).

						Averages.
Schultze, Old, 112grs. and 3oz. B.B.	Velocity	979	1013	1022	1023	1047 = 1017 ft.sec.
	Recoil	68·0	80·0	72·0	76·0	80·0 = 74·8 *ft.lb.*
Schultze, Hard, 112grs. and 3oz. B.B.	Velocity	1013	1117	1043	1048	1052 = 1054 ft.sec.
	Recoil	79·0	85·6	80·0	85·0	75·6 = 81·0 *ft.lb.*
E.C., 112grs. and 3oz. B.B.	Velocity	1019	1025	1026	1041	1043 = 1031 ft.sec.
	Recoil	79·4	82·0	82·0	84·0	84·0 = 82·3 *ft.lb.*
Amberite, Special, 112grs. and 3oz. B.B.	Velocity	995	1005	1008	1026	1053 = 1017 ft.sec.
	Recoil	78·0	82·0	78·0	78·6	81·0 = 79·5 *ft.lb.*
Amberite, No. 2, 120grs. and 3oz. B.B.	Velocity	994	1025	1042	1048	1060 = 1034 ft.sec.
	Recoil	71·0	82·0	79·4	80·0	74·0 = 77·3 *ft.lb.*
C. & H. No. 7, 9drs. and 3oz. B.B.	Velocity	980	988	990	993	993 = 989 ft.sec.
	Recoil	(beyond the limits of the recoil machine)				

The actual amount of recoil given by the black powder we are unable to state, the force being so great as to cripple our recoil machine; but we conclude it must have been considerably above 85 ft.lb., which was the highest record made by the nitro powders.

Velocities were not taken for the 5 yards range, owing to the machine-rest being damaged by the strain it had undergone; and the firing for patterns was made from the shoulder. One of the disadvantages of hang-fires was thus brought into prominence. When the special Amberite was being used, the shooter put the gun to his

shoulder and pulled the trigger; and so long an interval elapsed without the charge exploding that it was supposed there was a misfire; but just as the shooter was removing the gun from his shoulder, the explosion took place, driving back the gun with such force as to make his shoulder black and blue for days afterwards. After this, the trials for pattern with the special Amberite powder were not proceeded with; but those with the ordinary Amberite (No. 2), which did not hang fire, are given in the following tables:

PATTERNS of 3oz. B.B. (in 6ft. circle), at 60 yards range.

						Averages.
C. & H. No. 7, 9drs.	127	136	139	140	153	= 139
Schultze, Old, 112grs.	152	155	162	166	168	= 161
Schultze, Hard, 112grs.	97	122	124	158	171	= 134
E.C., 112grs.	119	157	169	164	173	= 156
Amberite, No. 2, 112grs.	139	150	152	154	162	= 151

PATTERNS of 3oz. B.B. (in 6ft. circle), at 80 yards range.

C. & H. No. 7, 9drs.	79	40	104	109	116	= 98
Schultze, Old, 112grs.	80	98	104	107	108	= 99
Schultze, Hard, 112grs.	68	94	98	102	110	= 94
E.C., 112grs.	97	98	98	105	112	= 102
Amberite, No. 2, 112grs.	90	95	98	101	108	= 98

It may perhaps be of service if we give a summary of the records made by both 4-bore and 8-bore, with the various powders. We will first summarise the records stated above, which show the following results:

SUMMARY OF RECORDS WITH 4-BORE GUN.

	Pressure.	Velocity.	Recoil.	Pattern.	
Powder Charges.	Tons.	Ft.sec.	Ft.lb.	60 yards.	80 yards.
Proof Powder, 18drs.	6·27	—	—	—	—
C. & H. No. 7, 9drs.	2·80	989	—	139	98
E.C., 112grs.	2·84	1031	82·3	156	102
Schultze, Old, 112grs.	3·12	1017	74·8	161	99
Schultze, Hard, 112grs.	3·01	1054	81·0	134	94
Amberite, No. 2, 112grs.	3·73	1034	77·3	151	98

The proof-charge of powder with the 4-bore is 50 per cent. greater than the proof-charge of the 8-bore; and it will be seen that there was a similar difference between the service charge of No. 7 black powder, as used in the two bores; but with the nitros there was not the same rate of proportion, as the charge of these powders was only raised from 84grs. to 112grs., an increase of one-third, whereas the full 50 per cent. would have raised it to 126grs. The quantity of shot used with all the nitros was the same as used with No. 7 black, viz., 3oz. of B.B. with the 4-bore, and 2oz. of No. 2 with the 8-bore; the proof-charge of shot is one-third heavier, and is No. 6 in size. The 8-bore records (of which detailed particulars were given in the article of May 12, p. 264) are summarised as follows; but we omit some records of smaller charges tried with Amberite and with the new hard-grained Schultze. The Walsrode leaflet powder, which was tried in the 8-bore, was not used in the larger gun.

SUMMARY OF RECORDS WITH 8-BORE GUN.

	Pressure.	Velocity.	Recoil.	Pattern.	
Powder Charges.	Tons.	Ft.sec.	Ft.lb.	60 yards.	80 yards.
Proof Powder, 12drs.	5·25	—	—	—	—
C. & H. No. 7, 6drs.	2·25	903	39·3	91	48
E.C., 84grs.	3·00	984	40·6	103	50
Schultze, Old, 84grs.	3·66	965	38·6	103	52
Schultze, Hard, 84grs.	3·99	1032	34·6	83	44
Amberite, 84grs.	3·07	1006	35·6	91	46
Walsrode leaflet, 50grs.	3·23	951	29·3	84	44

It will be observed that the amount of recoil appears to be very much less in proportion with the 8-bore than it does with the 4-bore. This is mainly due to the fact that the latter was a single-barrel gun, weighing 17lb., and consequently light in comparison with the double 8-bore of 13lb. 2oz. If the 4-bore gun had been a double gun, and increased in the same proportion as the shot-charge (viz., 50 per cent.), it would have weighed nearly 20lb., and the recoil record would have been very considerably lower. The fact has also to be taken into consideration that, with the black powder, the increase of charge was 50 per cent., and this added about 10 per cent. to the velocity with C. & H. No. 7; whereas the nitro powders were only increased about 33 per cent., and their velocity was much the same as in the 8-bore. The facts above mentioned may serve to explain how it was that the recoil records with the 4-bore appear so disproportionately large as compared with those made by the gun of smaller bore but comparatively heavier weight, and also how it was that the black powder happened to cripple the recoil machine.

There are certain seeming anomalies with regard to recoil; but they only confirm what we have previously said as to the fact that no one hard-and-fast rule will apply to different explosives. Here E.C. gave the lowest strain in the barrel of the nitros mentioned in these summaries, yet it showed the highest amount of recoil; and it also gave a capital pattern. Some of the other powders would doubtless have improved their patterns with rather lower charges. Indications of this were given in the previous article, where results of smaller charges of Schultze and Amberite were stated; but we do not include them here because they might tend to confuse the reader, and we think that the characteristics of the respective powders can be more satisfactorily compared when the charges used are equal.

NITRO POWDERS IN WILDFOWL GUNS.

(*Field*, Feb. 16, 1895; Vol. 85, p. 190.)

SOME undoubtedly good properties possessed by the nitro powders are sufficient in themselves to compel the earnest attention of wildfowlers, and to create the desire to see overcome any drawbacks prejudicial to their use in heavy wide-gauge guns. However hardly we may cling to our good old friend black powder, and however distrustful of innovations and conservative sportsmen may be, it must nevertheless, surely if slowly, be becoming a rooted conviction with most wildfowlers that the so-called smokeless powders are the powders of the future.

For game shooting, the several nitro-compounds have long held the field; for, if in practice these powders had not proved to be so regular as black, there are plenty of sportsmen who still would use them in preference on account of their excellent properties in the way of lessened noise, smoke, and fouling. These and other important advantages or improvements, however much needed in the matter of game shooting, are far more necessary as aids to success in wildfowl shooting; for, as is well known to practised fowlers, noise tends to disturb and frighten away the fowl, whilst an excess of smoke too often prevents the prompt use of the second barrel, and, at the same time, discloses the sportsman's whereabouts.

More important still, perhaps, than either of the advantages mentioned, is the comparative flamelessness of the nitro-compounds generally. For night-shooting—and much of the best wildfowl shooting in this country is done in the gloaming and at dead of night—this aphlogistic property of the nitro powders cannot be overvalued. I have frequently observed that fowl which rested undisturbed by the boom and the rousing echoes evoked by the discharge of a heavy punt gun in the twilight, would quickly spring to the flash and shower of sparks given off by the black powder from the overloaded gun of some old coast-gunner.

Another matter of vital importance to the users of big shoulder guns is the question of recoil. If it can be proved that this can be toned down or reduced by the use of a nitro powder, most big gun men will be quite ready to give the matter their more serious consideration. I am quite of the opinion that there would be more users of big guns, if it were not for recoil; for although to a certainty weight tells, still, after all, it is recoil that kills. Weight of gun is not the only factor determining the question of what we shall use in the way of wildfowl guns; for the weariness of a man tired by carrying a heavy load is as nothing compared with the feelings of one who has undergone a severe punching, and been well shaken up by a heavy and violent recoil oft repeated.

I have on various goose-shooting expeditions carried for many miles, over extremely rough ground, a 4-bore weighing three times as much as an ordinary game gun, without experiencing anything approaching to the discomfort I have felt after being mauled and pounded by a severer kicking gun of half the weight.

It must be said, however, that in judging of the weight and nature of recoil by the feelings alone one is apt to be misled; for according to the state of bodily health at the time, so will be the sensation produced by a normal recoil. The man with a liver, or the shooter of nervous temperament, will be liable to suffer far more discomfort from a moderate recoil than would a slimmer-built sportsman in robust health. This, possibly, may account to some extent for some extraordinary statements advanced from time to time with respect to recoil by men who should be qualified to speak, if lengthy experience in the shooting field counts for anything.

Although one's state of health is likely at all times to affect the rough and ready verdict given on recoil as felt in the field, the real point to consider is the kind of blow delivered by the gun on the shoulder; for, after all, I take it to be the speed of the blow and not the weight of it that tells. Thus the powder which is so consumed as to hit the gun back against the shoulder will punish the shooter far more than a slower-burning powder which thrusts gun and shooter back together. A powder doing its work near the breech of

the gun will, under ordinary conditions, exert greater strain at that part and kick sharper than a powder consuming gradually along the tube. And thus it may even be that a powder which by its violent impact moves the shot suddenly, so as to cause it to leave the cartridge at a high rate of speed, will exhaust itself sooner, and impart to its charge no higher muzzle velocity than a powder which, starting more moderately, gathers speed as it goes. The one is like a sprinter who starts off at a speed he cannot maintain, whilst the other may be likened to a runner who improves as he goes. Anything which delays the movement of the shot at the moment of starting—as, for instance, an undue turnover of cartridge case, a tightness or shoulder at the cone—is calculated to produce similar effects with a coarse slow-burning powder as might be obtained from a finer-grained powder meeting with no such obstruction.

Uniformity of size and density of grain are important matters in determining the regularity of shooting of any powder. I am quite of opinion that any powder which has a great percentage of small grains amongst the normal-sized grains, or a powder that, by reason of its friable nature, is liable to pulverise much, cannot be looked for to give the best and most regular results; as on occasion when an undue proportion of the dust or small grains gets collected by shaking or in other ways, and so is loaded into the cartridge case, it is likely to try both gun and shooter most severely. Mixed-grain powder may answer well so long as it can be kept duly mixed; but in practice I find that this cannot be ensured with powders, any more than was the case when mixed shot was recommended by some faddists for use in game guns.

In order to discover a really suitable and reliable nitro powder for use in duck-guns, I have, throughout the present season, been putting to a practical test upon wildfowl the capabilities of the three nitro-compounds Schultze, E.C., and Amberite, as used in 8-bores. Most wildfowlers of experience are aware that wildfowl guns may be broadly divided into two classes; in the first, we have guns bored to shoot with paper cases, and, in the second, the more modern brass-case gun, bored suitably to obtain the best results with the Kynoch thin brass "perfect" case. The prominent features of each style of gun having some years ago been thoroughly explained and compared in these columns, it will be unnecessary for me to dilate upon them now to any great extent. Suffice it to say, for the information of younger readers, or of any who may not have the facts fresh in mind, that the two guns, paper and brass case, are chambered to take a case of the same size externally, but, owing to the thinner material of the brass "perfect" cases, these are internally of greater diameter than the paper cases. Therefore we find in the brass case gun less difference between the diameter of the cartridge chamber and the bore of the barrel than occurs in paper-case guns, and thus the gun bored for "perfect" cases is larger than its nominal size—a 10-bore wad being required to fit a No. 12 cartridge case.

I have heard it asserted that nitro powders do not shoot so well in brass-case guns as in paper-case guns; and although I was prepared to find that this was so, and that the turning in of the paper cartridge case would be of material assistance to a slow igniting or burning powder, to so gather together its forces as to come through the ordeal fairly well as compared with its performance when loaded in the thin brass cases, nevertheless in practice I find that undeniably the nitros shoot well in brass cases and guns bored suitably.

The primary object of these tests was the subjecting the powders named to as full, complete, and practical a trial upon wildfowl under the usual conditions of the sport as pursued in this country. The *Field* having already given us most valuable information relative to the performance of wildfowl guns upon the target, there will be no occasion for me to again go into this matter: and, therefore, any results of target experiments that I may give are offered merely as being supplementary to the work in hand, and as affording some data wherewith to compare the actual performance upon fowl of the several guns, powders, and charges used.

Although not designed to be a test of the gun *per se*, I naturally selected as good and regular-shooting guns of each kind (paper and brass case) as might readily be obtained; so that after all, in addition to serving their ostensible purpose, these target trials may, in some degree, assist wildfowlers in arriving at some definite conclusion as to the performance of good shooting guns bored for the paper and brass cases when using the powders named. In the foregoing sentence I have used the term "in some degree" advisedly; for each season now brings with it a crop of new nitro-compounds, and, in addition, shows one or other of the old powders in a new guise; and, moreover, as the several powders now vary so much in behaviour one from another, and require to be applied so differently, the need for trials both at the target and in the field is more real and urgent than ever. If the shooting world could rest assured that a powder, once issued, could always be relied upon to possess the same properties, and that each "brew" could be implicitly trusted to display the same qualities as its predecessor, then truly might the sportsman say he was shooting with a certain powder. Now, however, save and except for the trials conducted by the *Field* from time to time, we are certain of little more than that the powder in use at the time being possesses the same name as before.

The father of our nitro powders, Schultze, appeared in a slightly altered form last year, it having been given to us in a much better condition for handling and loading, being so hard in the grain as to practically do away with one drawback so detrimental to the exhibition of regular and satisfactory results; for with the old Schultze, in common with all easily compressible powders, there was ever present the risk of over-ramming in the cartridge case when loading. In this respect, E.C. had already been improved some few seasons ago.

I will first give the record of the shooting of the paper case gun which I have been using this season; this gun I find to be a very regular performer. Each charge was weighed and cartridge loaded by myself; I shot the gun at the London Shooting School, firing from the rest, the spring of their recoil machine being screwed up to 20lb. The gun first used was the

PAPER-CASE GUN.

A full-choke double 8-bore paper-case gun by J. and W. Tolley, chambered to take 3¼in. cases, weight 14lb., target 30in. circle marked on large iron plate, distance 60yds., RIGHT BARREL, Eley's Gastight Cases, charge 84grs. SCHULTZE, 1 black-and-pink *Field* wad, ½in. soft felt, 1 card, 2½oz. No. 1 chilled shot 108 pellets per oz., 1 card and nice turnover.

Pattern on 30in. Circle.	Average pattern.	Hits on Card Rack, 8in. by 3in.	Average number of Strawboards penetrated.	Grand average penetration.	Highest number of Strawboards penetrated.	Average of highest penetration.	Recoil in pounds *above* 20.
76	70	3	19	19	22	23	70lb.
72		3	18		23		
69		5	22		26		
61		4	18		21		
74		2	18		23		
LEFT BARREL, SCHULTZE; charge, &c., as before.							
58	72	3	19	18	22	23	70lb.
72		2	17		20		
68		3	21		25		
79		4	19		27		
84		4	17		22		
RIGHT BARREL, E.C. Powder; 84grs., wadding, shot, &c., as before.							
58	66	3	20	19	23	22	67lb.
64		3	18		21		
74		3	17		25		
67		4	24		22		
69		3	19		21		
LEFT BARREL, E.C.; charge, &c., as before.							
78	71	3	21	21	24	24	70lb.
68		4	19		22		
70		5	23		26		
76		4	24		27		
69		3	21		22		
RIGHT BARREL, AMBERITE; charge 80grs., wadding, &c., as before.							
53	65	2	19	19	26	23	69½lb.
62		3	18		23		
65		2	21		21		
71		4	22		25		
74		5	18		20		
LEFT BARREL, AMBERITE; charge, &c., as before.							
57	65	2	22	21	24	23	69lb.
72		3	22		25		
69		2	19		20		
67		4	24		26		
61		2	19		21		
RIGHT BARREL, BLACK Powder (C. & H., T.S., No. 4 grain); charge 168grs., with wadding, &c., as before.							
58	63	2	27	23	29	28	81lb.
49		3	22		24		
69		3	22		26		
74		3	25		31		
66		4	23		30		
LEFT BARREL, BLACK; charge as before.							
61	70	2	23	22	30	29	79lb.
83		5	24		31		
67		4	22		28		
70		3	20		26		
71		3	24		31		

As in the course of the foregoing experiments I had several noticeable or bad hang-fires with the Amberite powder, and also on one or two occasions a slight hang with both Schultze and E.C., I determined to try Kynoch's Perfectly Gastight Cases, and with the following result:

RIGHT BARREL, SCHULTZE, in Kynoch's P.G.T. Cases; load as before.

Pattern on 30in. Circle.	Average pattern.	Hits on Card Rack, 8in. by 8in.	Average number of Strawboards penetrated.	Grand average penetration.	Highest number Strawboards penetrated.	Average of highest penetration.	Recoil in pounds *above* 20.
64	66	3	19	19	27	24	72lb.
56		1	22		22		
75		4	18		24		
70		4	19		26		
67		3	17		21		
LEFT BARREL, SCHULTZE.							
85	70	5	21	18	28	22	71lb.
76		3	18		22		
49		1	19		19		
71		2	17		18		
70		3	19		25		
RIGHT BARREL, E.C. Powder; load, &c., as before.							
65	68	5	20	20	26	26	75lb.
74		3	18		23		
81		6	21		29		
52		2	22		30		
68		4	19		23		
LEFT BARREL, E.C. Powder.							
72	70	4	19	19	26	24	71lb.
53		2	19		24		
77		3	19		22		
68		2	20		24		
80		8	21		27		
RIGHT BARREL, AMBERITE; charge 80grs., and wadding, &c., as before.							
56	66	1	24	21	24	24	70lb.
67		4	20		26		
74		3	22		24		
78		4	19		21		
55		2	21		25		
LEFT BARREL, AMBERITE.							
73	62	5	19	19	30	25	70lb.
49		2	19		25		
65		3	23		25		
71		7	20		26		
55		3	17		20		
RIGHT BARREL, BLACK (C. & H., No. 4 grain, T.S.); 168grs. charge, as before.							
67	64	3	24	22	27	28	80lb.
60		3	20		28		
74		5	22		31		
66		4	20		25		
54		3	27		30		
LEFT BARREL, BLACK.							
68	60	2	22	21	31	28	78lb.
58		2	21		23		
49		2	20		30		
57		4	24		29		
68		4	22		30		

I found the ignition of the Schultze and E.C. powders to be much more perfect with Kynoch's caps; also that with Amberite the hang-fire did not occur so often, and, when it did occur, it was not of such long duration. Apart from spoiling one's sport, this question of hangfires may not at first sight appear to be of much moment. They must, however, be guarded against as a possible source of danger. Otherwise, in an unguarded moment, the shooter might relax his grip of the gun too soon, and thus receive a blow sufficient to break his collar bone, or dislocate wrist, thumb, or finger; for these guns with their heavy recoil are not toys to be played with. Or, again, when firing a quick right and left, should the first barrel hang fire and the second go off smartly, it would amount to a simultaneous discharge, and then, possibly, something about the gun might be strained or have to give way. The more I see of it, the more am I becoming convinced that the question of suitability of ignition plays a vastly important part so far as our nitro powders are concerned. Indeed, so vital a matter is this, that the question of the cap will determine whether a powder may be used or not.

In the foregoing trials I do not pretend for one moment to say that the best charges of the respective powders were used either (1) as regards the most suitable quantities for the gun itself, or (2) with respect to the proportion of powder to shot; and I should look for some slight modification of result, say, when the powder charge was increased, but still not sufficient to affect the verdict as between the powders to any appreciable extent.

I have taken considerable pains to put the matter as plainly as possible, taking the penetration as shown by the card rack as being at once the clearest and most palpable proof of the driving powers of the several powders. The card rack contrivance for testing the penetration of the shot pellets is as simple as possible, and it possesses some important advantages over Pettit's pads. In the former, the holes are punched clearly and distinctly in the strawboards, and the pellet, having done its work, drops into the space beyond the last hole punched. In going through the pad, however, the pellets do not punch clean holes; for the sheets of brown paper are held tightly together, and, as a consequence, a pellet may break many more sheets than it actually pierces; and as the paper punched out from the first few holes is apt to drive along in front of the pellet, it so retards its progress as to make the test unfair and unreliable, both as regards the force exhibited by the shot of one size, pellet to pellet, and also with respect to the force displayed by larger shot as compared with smaller pellets. The record of the shooting of the brass case gun, along with my experience in other respects, must be deferred for another article.

HENRY SHARP.

(*Field*, March 2, 1895; Vol. 85, p. 257).

A MATTER of vital importance as affecting the range and penetration of the shot is the bruising of the pellets within the gunbarrel. When conducting the foregoing tests, I found, on shooting at the strawboards, that many of the pellets were much knocked about—in fact, rendered quite shapeless. In nearly every instance it was observable that these battered pellets were the laggards in piercing the strawboards, and that, in just proportion to the rotundity of the pellets, so was their penetration. A perfectly spherical pellet of No. 1 shot would pierce twenty-six or more of the strawboards at 60 yards; whilst in many instances the battered missiles did not get through half that number of sheets. This deformation of the shot, whether caused by the first jamming together on the impact of the powder explosion, or by the severe constriction in passing through the choke, undoubtedly interferes with their penetration, and therefore with the range of the gun, in a most marked manner. It may be that the severity of the choke is in some measure answerable for this, and that, by putting so great an amount of constriction upon the shot, the gunmakers possibly are defeating their own ends, in that the primary purpose for which wildfowl guns are constructed, viz., length of range, is to some extent interfered with. The chilled shot does not appear to be made so hard as formerly, and this, I take it, is a disadvantage where crushing of the pellets occurs. In my opinion, it would be well to sacrifice a modicum of weight for hardness, if by so doing sphericity of the pellets is retained; for although the greater the specific gravity of the pellets the better, as assisting towards directness and length of flight, yet a mis-shaped heavy pellet will not travel so straight as a lighter and rounder pellet, while it is liable to be outdistanced. I will next give the result of my target experiments with the

BRASS-CASE GUN,

a full-choked double (nominal) 8-bore by W. W. Greener, chambered to take Kynoch's thin brass "perfect" 3½in. case, and weighing 16lb. Before proceeding farther it may be as well to point out, lest it should escape notice, that, by reason of their larger gauge, guns of this class cannot be placed in the same category as the paper-case guns (being almost 6-bores in point of fact); for I find that the internal diameter of the thin brass "perfect" No. 8 cartridge case gauges ·896in., or exactly 6½-bore—*i.e.* midway between 6 and 7 gauge. This gun I also shot at the grounds of the London Shooting School at the same large "plate" as before, the distance again being 60 yards. The cartridges were loaded by the maker of the gun.

SCHULTZE POWDER (Right Barrel).

Charge 84grs., one black-and-pink "Field" wad, one thick felt, another "Field" wad, 2½oz. No. 1 shot, and thin card.—N.B. I find, on weighing and counting two or three samples, that this shot counts only ninety-six pellets to the ounce.

Pattern on 30in. Circle.	Average pattern.	Hits on Card Rack, 8in. by 8in.	Average number of Strawboards penetrated.	Grand average penetration.	Highest number of Strawboards penetrated.	Average of highest penetration.	Recoil in pounds *above* twenty.
91	82	4	20	22	29	30	66½lb.
79		3	24		33		
72		4	21		29		
87		5	23		31		
83		4	23		28		

LEFT BARREL, SCHULTZE; charge, &c., as before.

56	83	4	19	20⅝	30	29	65lb.
94		4	23		28		
87		4	20		31		
88		2	21		26		
90		5	22		30		

RIGHT BARREL, E.C. Powder; 84 grs., wadding, shot, &c., as before.

93	86	6	24	21⅜	32	29⅝	67lb.
74		2	19		27		
87		4	23		30		
90		4	21		31		
88		3	22		29		

LEFT BARREL, E.C.; charge, &c., as before.

66	76	2	23	21½	27	29	65½lb.
84		4	23		27		
71		4	23		33		
87		3	20		30		
74		2	19		29		

RIGHT BARREL, AMBERITE Powder; charge 90grs., wadding, &c., as before.

86	84	2	24	21	26	27⅜	65lb.
85		4	22		31		
77		2	18		23		
87		4	22		30		
84		2	19		30		

LEFT BARREL, AMBERITE Powder; charge, &c., as before.

73	75	3	25	22	32	29	66lb.
73		5	23		29		
85		3	20		26		
68		3	19		30		
80		3	23		28		

RIGHT BARREL, BLACK Powder (presumably Pigou, Wilks, and Laurence's "Alliance," No. 4 grain); charge 168grs., wadding as before.

83	86	4	23	22⅝	30	29	74lb.
94		2	19		26		
77		2	23		33		
89		4	23		28		
90		4	20		29		

LEFT BARREL, BLACK; charge, &c., as before.

91	83	2	27	23⅛	32	29⅝	74½lb.
75		4	21		31		
78		1	26		26		
90		5	23		33		
82		2	20		28		

The crushing of the shot pellets was to be observed also with the Greener gun; and, from what I have seen, I am convinced that this may easily rob a gun of at least 25 per cent. of its effective killing power. Some may urge that a mis-shapen, angular pellet will deal a more telling and deadly blow, and cause fowl to collapse much quicker than will a round pellet, which penetrates with comparatively little shock. This argument might hold good supposing the battered missile reaches the fowl, which is extremely problematical at long ranges; but, even if it does get there, it certainly is not in the best form for piercing the strong feathers and downy covering of the geese and ducks.

The loads used of the nitro powders in the foregoing tests are rather light in proportion to the weight of shot; and they certainly, so far as the weight of the gun and the recoil as felt at the shoulder is concerned, may be increased without sacrifice of comfort or safety. A charge of these powders equivalent to 7drs. of black powder would appear to be a somewhat more proportionate charge for driving the 2½oz. of shot with greatest effect. I therefore loaded some cartridges with exactly 100grs. of Schultze and E.C. (98grs. would be the equivalent of 7drs. black, but I put the 100grs. measure in my scales for uniformity), and 94grs. of Amberite. These cartridges I have been using on tough fowl, like brent geese and sea-going ducks, with eminently satisfactory results. HENRY SHARP.

(*Field*, March 26, 1898; Vol. 91, p. 445.)

CONCENTRATED NITRO-COMPOUNDS.

THE work of finding out suitable charges of the concentrated powders for use in heavy shoulder duck guns is slowly progressing. But this matter of fixing the charges for 4-bores and 8-bores, as I have previously remarked, is not altogether plain sailing. The powder manufacturers themselves have not, in this respect, much information to give respecting their several productions — these newer forms of nitro-compounds—they having been more professedly designed for use in 12-bores and ordinary game guns. Thus, having so few data to work upon, the task has practically had to proceed *ab initio*. I have, therefore, sought the assistance of my very good friend Mr H. F. Phillips, in order that he—aided by those scientific instruments which have already recorded so many valuable experiments for the benefit of readers of this paper—might give me some idea as to the charges of various condensed powders suitable for use in 4-bore and 8-bore shot guns. The aid thus rendered has lightened my labours very considerably; indeed, it will be patent to all who have given the subject any consideration that in the fixing up of suitable proportions of powder to shot more may be learnt by the aid of the chronograph and pressure gauges in one day than can be gathered in a whole week of shooting at the target and penetration cards. Moreover, the velocity to be imparted to the shot is not the sole consideration in trials of the sort; the question of the pressures given by the powder upon explosion is naturally matter for careful research.

The man who uses black powder feels tolerably well assured as to the effects that will be produced on using increased charges of his favourite powder. He, often enough, runs on the assumption that two and two make four, and acts accordingly. Not so the nitro man; for he is fairly well aware that, in his case, the result obtained by an increase of the powder charge is not exactly a question of simple addition; as two and two may, so to speak, make six, eight, or even more. In other words, the doubling of the powder charge, such as takes place in duck guns, will almost certainly be productive of results that do not show an increase in a ratio strictly proportionate to the augmentation, if we take black powder as the standard for comparison. I have frequently come across, and I daresay others have also, the professional coast gunner, whose favourite powder measure for his shoulder duck gun is the bowl of a clay tobacco-pipe. With this he trundles, and unstintingly, two or three, perhaps four, of such rough measures of black powder into his piece, according to its capacity and weight. With the more extended use of nitro powders and breech-loading guns, all such rough and ready methods of loading are sinking into desuetude; so much so, in fact, that at the present time the breech-loader is oftener to be found in the hands of the professional wildfowler than is the muzzle-loader—this, by reason of the handiness, quickness, and certainty of the former, as well also from the fact that the method of loading with cartridges at the breech lends itself more readily to the use of nitro-compounds, and not altogether, as some might suppose, because good results cannot be obtained with a nitro powder in muzzle-loading guns. It certainly is somewhat difficult to get uniformly good results with nitro powders out of a muzzle-loading gun; but I distinctly remember shooting fairly well with Schultze soon after that powder came out, loading it carefully into a 13-bore muzzle-loader that I possessed at the time. That was in the old days, when that explosive was widely known amongst sportsmen and gunmakers as "sawdust" powder, and long before it was presented in its present rounded granular form.

Of the vast number of useful things in this world of which people are happy to be possessed, few are scarcer than 4-bore crusher gauges. In all probability the grand total of their number may readily be summed up on the fingers of one hand. My sense of obligation—and, so I take it, that of the 4-bore men amongst my

readers—to Mr Phillips is therefore greater in that he has undertaken to ascertain the pressures, and also, by means of the chronograph, the shot velocities of certain charges of the concentrated nitro powders loaded in 4-bore cases. Below are given the results of a trial of the Walsrode, Shot-gun Rifleite, and Normal powders. These certainly are pleasing, for with these charges considerable uniformity is attained in the matter of both pressures and velocities. This uniformity is all the more noticeable if one has regard to the fact that the powders named were more especially designed for use in guns much smaller than a 4-bore. The tables appended would, however, seem to establish as a fact that the powders named may be advantageously used in a gun of this size. The velocities are as high as need be desired, whilst the pressures recorded are not too high for use in guns of sound construction, substance, and weight. Higher velocities might be secured, but as their attainment would necessitate a corresponding increase in the pressures, I think that the sportsman will rest contented with those obtained. The velocity of 1300 feet per second, at a range of 10 yards from the muzzle of the gun, imparted to the shot by these powders, should surely be enough to satisfy most people even at the present advanced stage of gun and powder manufacture.

The three kinds of powder were loaded in similar fashion, except that the charge of Walsrode was 75grs, that of Shot-gun Rifleite 85grs, and that of Normal 80grs.; the charge of shot throughout was 3oz. of No. 1; the wads for Walsrode and Shot-gun Rifleite were,—first a "Field" wad, then four ⅜-inch felts and thin card, with a thick card over the shot; but with Normal, owing to difference in bulk of the powder, there were three felts instead of four, and a pink-edge wad, the rest being as before stated; Eley's red Walsrode cases were used with all the powders. The results were as follows:

(Barometer, 29·44in.; Thermometer, Wet bulb, 39°; Dry, 39°.)

	Velocities (10 yards) in feet per second.					Averages.
Walsrode	1245	1260	1240	1267	1235	1255 = 1254
S. G. Rifleite	1364	1345	1339	1351	1339	1327 = 1344
Normal	1316	1316	1327	1293	1304	1277 = 1306

	Pressures in Tons per square inch.					Averages.
Walsrode	2·97	3·40	2·91	3·40	3·28	3·09 = 3·15
S. G. Rifleite	3·36	3·02	3·56	3·06	3·42	3·28 = 3·29
Normal	3·92	3·80	3·72	3·62	4·00	3·76 = 3·80

Half a dozen 4-bore cartridges sent to me by Messrs Nobel were then tried by Mr Phillips. These were charged with Ballistite of slightly altered form. This powder is granulated somewhat differently from the ordinary game-shooting Ballistite, and is expressly designed for use in 8-bore and 4-bore duck guns. This powder was loaded in Eley's yellow "Pegamoid" paper Ballistite cases, with deeply coned base; the charge being said to be 85grs. to 3oz. BB shot, but this could not be verified, as the whole of the cartridges were expended in the trial, the results of which are now given:

(Barometer, 29·44; Thermometer, Wet bulb, 39°; Dry, 39°.)

	Velocities (10 yards) in feet per second.		Averages.
Wildfowling Ballistite	1339	1360	1332 = 1360

	Pressures in Tons per square inch.		Averages.
Wildfowling Ballistite	2·58	2·20	2·42 = 2·40

I will now give the results of some trials at the target of the four concentrated nitros mentioned, first taking

Walsrode.

The gun used in this and the following trials was the same as used by Mr Phillips, viz., a single 4-bore weighing 13lb. 4oz., barrel 41in. in length, makers Messrs Thomas Bland and Sons, London and Birmingham. The Eley red paper Walsrode cases were used, the powder charge being 75grs. and the weight of shot 3oz. I had intended using No. 1 shot of 104 pellets to the ounce, but found that shot of this size was unprocurable at the moment, several samples counted falling below or rising considerably above the particular size specified. I had therefore to fall back upon a size of soft or unhardened shot counting 270 pellets to the 3oz. charge employed, this being the No. 1 of certain shot manufacturers. The wadding and turnover of cases was the same as in the cartridges used in the foregoing trials. Thus, in the case of the 4in. cases used, about an inch of useless lumber, in the form of wadding, is necessary to fill the space so as to insure the proper amount of tube being left for the turnover. It would therefore be possible to have the cases for this powder no more than 3in. in length—truly a great gain for the sportsman. The gun was fired from a rest, the distance in every case being 60 yards, the pattern being counted within a 30in. circle.

	Patterns.					Average.
Walsrode	84	39	40	38	61	56 = 53

Penetration.

Walsrode....	Hits on card rack, 9″ × 9″.	Average number of strawboards penetrated.	Grand average penetration.	Highest number of strawboards penetrated.	Average of highest penetration.
	1	22	18	22	20
	0	—		—	
	3	15		19	
	1	21		21	
	1	20		20	
	4	15		19	

This is a remarkably clean powder, scarcely any residuum left in the barrel. The ignition was perfect, there being not the slightest symptom of a hang-fire.

Shot-Gun Rifleite.

The gun, cartridge case, wadding, and load of shot were the same as in the foregoing trial, but the powder charge was 85grs.

	Patterns.					Average.
S.-G. Rifleite	50	48	64	65	73	56 = 59

Penetration: 1 pellet through 23 strawboards.

On testing this powder for penetration, it was rather disconcerting, not to say annoying, to find that in the whole series of six rounds one pellet only entered the aperture of 8″ by 3″ left on the target for the card rack. Two or three pellets glanced off the edge of iron plate, and so into the hole, but these, of course, penetrated but a few sheets, and so were not counted. An unfortunate series such as this might not occur once again in one hundred trials of the sort.

This powder also was remarkably clean, scarcely soiling the gun-barrel in fact, and there were no hang-fires.

Normal.

Of this powder the charge used was 80grs., and, owing to its being slightly bulkier than the others, only three felt wads, instead of four, besides a pink edge, and two card wads were used. The other conditions were exactly the same as in the foregoing trials.

	Patterns.					Average.
Normal	72	62	52	76	62	60 = 64

Penetration.

Normal.	Hits on card rack.	Average number of strawboards penetrated.	Grand average penetration.	Highest number of strawboards penetrated.	Average of highest penetration.
	4	22	22	26	24
	0	0		—	
	2	25		26	
	2	23		24	
	1	20		20	
	3	22		25	

There were no hang-fires with this powder; and it, too, is very clean.

Wildfowling Ballistite.

Messrs Nobel have been at considerable pains to meet my wishes, for not only have they produced coned-base 4-bore and 8-bore cartridge cases with suitable caps, but a special form of Ballistite has been made expressly for use in guns of this size.

For this trial the powder charge was 88grs., in Eley's primrose-coloured "Pegamoid" paper Ballistite case with deep-coned base; the shot charge being 3oz. of chilled No. 1, counting 313 pellets to the full charge; a thin card overshot wad, with an ⅛in. card, ¼in.

feltine, ½in. soft felt, and another ½in. card over the powder, leaving sufficient tube for a good turnover.

	Patterns.					Average.
Wildfowling Ballistite...	125 ...	112 ...	95 ...	120 ...	130 ...	123 = 117

Penetration.

Wildfowling Ballistite.	Hits on card rack.	Average number of strawboards penetrated.	Grand average penetration.	Highest number of strawboards penetrated.	Average of highest penetration.
	8	24	23	28	27
	6	22		29	
	3	26		29	
	1	22		23	
	6	27		29	
	8	21		26	

All the patterns made with this powder were most evenly distributed on the target. The ignition and combustion appeared to be perfect, a residuum of fine dust only being left in the barrel after each discharge. One very noticeable feature of the foregoing trials was the marked superiority of the chilled over the soft shot in the matter of penetration. It was found on taking the pellets from the card rack that the soft shot had been completely knocked out of shape within the gunbarrel, whereas the form of the chilled shot pellets had been much better preserved. The soft shot were so greatly crushed and indented that, although much weightier individually than the hard shot, they fell considerably behind the latter in the matter of penetration. I have previously had something to say in these columns respecting the crushing of the shot pellets. It is a matter of considerable importance where the killing of wildfowl at long ranges is involved, and I may therefore revert to this subject again when I have had a more extended opportunity for testing chilled and soft shot side by side.

I will now give particulars of some shooting I have done with loads based on the results of the foregoing researches.

Walsrode in 4-Bores.

This explosive was, I believe, the pioneer of the concentrated powders now before the sportsman; and therefore with it—as I am not forgetful of the old adage of one's schoolboy days respecting the senior's right of priority—I commence my report. A beginning was made with 75grs. of Walsrode and 3oz. of No. 1 and larger sizes of shot, in Eley's paper cases made especially for this powder; these have large caps, and the interior of the base of the cartridge case is slightly cupped, or what is technically termed coned. These small charges of powder occupy so little room in the 4in. case that three and a half, sometimes even four, felt wads had to be employed to fill up the space, so as to allow a proper amount to be left for the turnover.

One can entertain but few doubts as to the various important changes that will eventually ensue whenever the time comes for the concentrated powders to be more fully adopted. It is perhaps only a question of time before this takes place. I have not the slightest doubt that these higher forms of explosives are certain to be much used for wildfowling purposes—provided, of course, that they are found to be thoroughly reliable and controllable when fired in the large charges necessary for wide-bored shot guns. This being so, one can plainly foresee changes more or less great that will be called for in the direction of a shortening of the cartridge case, and also of the gunbarrel, thus rendering both gun and ammunition more portable; this, truly, will be a great gain, and one for which all wildfowlers will doubtless be sufficiently grateful.

There is for the wildfowler something peculiarly fascinating in the idea of a waterproof powder, by reason of the fact that the sport he follows is nothing if not humid. We are assured that this powder now under discussion, as well as others of concentrated form, are practically impervious to damp. This, then, will be a great boon to the wildfowler, whose chief concern hitherto in all his wanderings has been to keep his powder dry. It is rather startling to find our very earliest and most deeply rooted convictions respecting the attributes of gunpowder so completely upset by the terms "waterproof," "damp-proof," &c., which are bestowed upon the explosives of the day. Still, the most ultra-conservative sportsman amongst us must rejoice over the fact that the affinity for moisture exhibited by our old servant black powder is not shared by some of the later issued nitros.

The gun used for the purpose of testing Walsrode and one or two other concentrated powders on wildfowl is a powerful double 4-bore, made by Messrs Joseph Lang and Son, Pall Mall, S.W. It is a swivel gun weighing something over 25lb., and has proved to be remarkably handy and efficient, both on board a punt and in a small sailing yacht, whenever it has been found possible to use it—which certainly has not been often, owing to the extremely mild character of the past wildfowling season.

Some few weeks ago I went aboard the tight little yacht which has carried me safely on many wildfowling expeditions. It was Thursday midnight, and I intended stopping on board for a couple of days. The wind was strong from the south-west, and, as our anchorage had been chosen not so much for shelter as to suit my convenience, the little craft rolled pretty considerably that night, particularly at about the time of high water, when we were exposed to the full force of the wind and waves. The following morning the anchor was weighed and we were under way some little time before daylight came. Sunrise found us making the best of our course for some sandbanks where there was shelter as well as feed for the fowl. On our way we fell in with a party of scoters. These diving ducks—known locally as black ducks—appear to find that particular spot to be much to their liking, for they have been observed there all the past winter. I determined to take a shot at them on purpose to try the gun and powder. They were so much scattered that a really effective shot could not be made, and a right and left from the double 4-bore, with No. 1 shot, at about seventy yards, stopped only three birds. As, however, two of them were stretched out quite dead, I was well satisfied with the result of this, the first shot with Walsrode; for after a shot at these dusky fowl, at anything but the closest range, it is quite the usual thing to find many more birds wounded than killed. Scoter No. 3 was so lively that we went to secure him first; this, however, we found to be impossible, for after giving us a remarkable exhibition of his diving powers he vanished we knew not where. After making one or two tacks in the choppy sea in the vain endeavour to sight this wounded bird, we relinquished the chase and went in quest of the dead birds, which by then had drifted some considerable distance on the tide. On recovering these, we found that one was killed with a shot through the head, whilst the other had been effectually stopped by two pellets that had penetrated deeply into the side and breast.

With one exception, the remainder of that day was uneventful so far as shooting afloat went. We had been cruising about for several hours trying to obtain a shot at several small groups of mallard and one lot of shellducks that were viewed, but without success. At length, however, our efforts were rewarded by obtaining a fairly good shot at three ducks. As soon as I could distinguish the sex of the birds—there were two drakes and one duck in the little group—I trained the gun on to them in the determination to take one shot on the water and the other in the air. When we had approached within a hundred yards or so they showed signs of alarm, but we gained another ten yards before they turned head to wind with the evident intention of springing. Then I instantly pulled trigger. The aim, however, was defective, for the boat was jumping about a bit, and the shot striking short no harm was done. The second barrel, however, rectified the mistake somewhat, for, on taking careful aim well above them as they sprang into the air, I had the satisfaction to see a fine mallard tumble headlong into the water. This bird was struck through the neck and under the wing by two single B pellets, and was giving its last kick when gathered in the landing net.

That evening I went ashore for flight, taking with me a stout single 8-bore and cartridges loaded with 50grs. of Walsrode and 2¼oz. of No. 1 shot. It was a very bright evening, and the ducks came in sky high. Three shots were fired, all of them at great distances, and one duck was brought down whilst flying past alone at fully sixty yards distance.

Henry Sharp.

TRIAL OF 8-BORE DUCK GUN WITH DIFFERENT SIZES OF SHOT.

(*Field*, Nov. 9, 1895; Vol. 86, p. 751.)

Sir,—I feel sure it would be a very great boon to wildfowlers in general to receive some enlightenment as to the extreme distances at which the various sizes of shot in use for wildfowling retain sufficient penetration to kill clean. There is, I am afraid, at present much divergence of opinion in this respect, my shooting friends using everything from No. 6 to BB.

My own impression is that the shot to be used should be the smallest possible, consistent with sufficient killing power, up to say between 80 to 100 yards; but the difficulty lies in ascertaining what size this is.

Now, Sir, knowing your anxiety to support and foster every description of sport, I would ask if you can kindly see your way to promote, through the agency of the *Field*, some experiments in this

direction, which would, I am sure, be hailed with delight by all wild-fowlers as setting aside for once and for all the, at present, very much debatable question of penetration at extreme ranges of various shot in connection with wildfowl guns. E. J.

[In accordance with our correspondent's request, we have carried out some experiments, at 80 yards and 100 yards, with three sizes of shot, with an 8-bore single duck gun, bored for "perfect" cases, and made by Messrs. J. and W. Tolley, of New Bond-street, London. The same charge (7drs. of C. & H. No. 7 powder and 2½oz. of shot) was used throughout the trial. In the 2½oz. charge of BB shot there were 190 pellets; in an equal weight of No. 1 there were 260 pellets; and of No. 2 there were 305 pellets. The penetration was taken by one of Messrs. Cogswell and Harrison's straw-board racks. The results obtained by firing six rounds of each kind of shot, at the two ranges, were as follows:

EIGHTY YARDS RANGE.

	Patterns in 30in. circle.						Average.
BB	22	27	20	25	30	28	= 25
No. 1	34	26	29	29	42	37	= 33
No. 2	33	45	50	47	38	48	= 44

	Penetration of straw-boards.						Average.
BB	22	27	23	28	30	25	= 26
No. 1	15	14	18	16	22	21	= 18
No. 2	10	15	15	12	16	16	= 14

ONE HUNDRED YARDS RANGE.

	Patterns in 30in. circle.						Average.
BB	14	20	14	17	12	12	= 15
No. 1	20	17	14	18	18	22	= 18
No. 2	20	19	23	27	27	21	= 23

	Penetration of straw-boards.						Average.
BB	13	17	12	19	13	14	= 15
No. 1	11	9	8	11	10	9	= 10
No. 2	10	9	6	7	9	9	= 8

No. 4 shot was also tried, both at 80 and 100 yards; but the penetration was not sufficient, and the pattern was too much scattered. No. 2 shot, in our opinion, is the smallest size that should be used between 80 and 100 yards range.

The weight of the gun was 14½lb.; length of barrel, 37in.—Ed.]

KILLING CIRCLE OF WILDFOWL GUNS.

(*Field*, May 26, 1894; Vol. 83, p. 733.)

Sir,—A short time ago your correspondent "Sheldrake" suggested that it would be interesting to know how many single ducks would be bagged by an 8-bore, at 60, 70, and 80 yards, with Nos. 1, 2, 3, and 4 shot.

We have made the experiment at the tracing of a plucked mallard, broadside on, with a double 8 bore, having 36in. barrels, weighing 12lb., and having the reputation for being a good one.

The load throughout was 6drs. C. & H. No. 7 black powder, and 2½oz. shot (Walker's chilled). All the rounds were central.

Round.	Shot.	60 yards.		70 yards.		80 yards.	
		Pellets hit.	Result.	Pellets hit.	Result.	Pellets hit.	Result.
1	No. 1. 2½oz. (equal to 195 pellets)	2	1 fatal	0	0 fatal	0	0 fatal
2		2	2 "	0	0 "	0	0 "
3		1	0 "	2	2 "	2	1 "
4		1	1 "	0	0 "	0	0 "
1	No. 2. 2½oz. (equal to 275 pellets)	2	1 fatal	0	0 fatal	2	1 fatal
2		2	doubtful	1	1 "	2	0 "
3		0	0 fatal	1	1 "	0	0 "
4		0	0 "	0	0 "	2	2 "
1	No. 3. 2½oz. (equal to 350 pellets)	3	2 fatal	1	doubtful	0	0 fatal
2		2	1 "	0	0 fatal	0	0 "
3		4	2 "	1	1 "	0	0 "
4		1	1 "	1	0 "	1	1 "
1	No. 4. 2½oz. (equal to 446 pellets)	0	0 fatal	2	2 fatal	0	0 fatal
2		4	4 "	3	1 "	0	0 "
3		2	2 "	1	0 "	1	1 "
4		2	2 "	4	4 "	2	1 "

Summary.

	No. 1 Shot.		No. 2 Shot.		No. 3 Shot.		No. 4 Shot.	
	Pellets hit.	Kills.	Pellets hit.	Kills.	Pellets hit.	Kills.	Pellets hit.	Kills.
60 yards	6	3	4	1	10	4	13	3
70 yards	2	1	2	2	3	1	10	3
80 yards	2	1	6	2	1	1	3	2
Totals	10	5	12	5	14	6	26	8

From the foregoing figures, it will be seen that the smallest shot gave the best results, on account of the increase of pattern in the charge. It is interesting to estimate what the results would have been had one size of shot for the forty-eight rounds been used—*e.g.*:

No. 1 would have hit with	40	pellets, and killed	20	ducks.
No. 2 "	48	" "	20	"
No. 3 "	56	" "	24	"
No. 4 "	104	" "	33	"

If any of your readers have an exceptionally good 8-bore, and would like it tried in the same way as we have done in this instance, they may send it to us, with suitable cartridges, carriage paid, and we shall be happy to test it, and to send you the results for publication.

London Shooting School Company.

Willesden Junction, N.W., May 21, 1894.

[The new address of this company is London Sporting Park, Hendon, N.W.]

TRIAL OF NEW SAMPLES OF NITRO POWDERS.

(*Field*, June 30, 1894; Vol. 83, p. 962.)

Schultze and Amberite.

Many are the changes which have been introduced into the manufacture of nitro powders in recent years, and remarkable are the differences, in appearance as well as effectiveness, between the numerous smokeless explosives of the present day and the very limited number which were in existence a decade or two ago. Few persons whose acquaintance with Schultze powder has been made since it assumed its present granulated form would be likely to recognise the "fluffy" orange-coloured material sold under the same name about a quarter of a century ago, or the "cubical" grains which were afterwards adopted, and which led to its being called "sawdust" powder; yet the "fluff," the "sawdust," and the present round granules are practically the same in their chemical constituents, being composed of lignine or wood fibre which has been submitted to the action of nitric acid; the differences are due to modifications in the process which have been introduced with the view of obtaining greater reliability and uniformity of result.

The latest change in the process of manufacture of the Schultze powder has been the hardening of the grain, with the view of preventing the bad results which not unfrequently arise from careless loading and over-ramming of the cartridges. We have had sent to us, from time to time, many samples of cartridges which have been forwarded by correspondents who have requested us to tell them why they shot so badly; and it has not unfrequently happened that, instead of the powder being at fault, the results complained of were entirely due to the badness of the loading, the cartridges sometimes having been rammed with such excessive force as to squeeze the powder into a nearly solid block. In order to prevent this in future, a new process has been introduced into the manufacture, whereby the powder grains are hardened, and thereby rendered practically incompressible. This hardening of the grain has also the effect of rendering the powder less sensitive to heat and drying. Some of the hard-grained Schultze powder having been sent to us for trial, we tested it under the conditions stated below.

At the same time we took the opportunity of testing a new sample of Amberite powder (No. 2) made by the Clyde Mills Company. This also is an improvement on the Amberite powder (No. 1) that we formerly reported on. For the sake of comparison, we also tried some black powder (Curtis and Harvey's No. 4 treble strong) under the same conditions; and we give the records below. We have not printed the respective rounds in the order in which they were fired,

but have arranged them numerically, so as to enable the variations to be more easily compared one with another.

PATTERNS made by 1¼oz. of No. 6 shot, in 30-inch circle, at 40 yards.

											Averages.
C. & H. No. 4, 32grs.....	96	173	193	193	195	196	200	203	217	222	= 189
Schultze, Old, 42grs.....	217	218	220	227	230	231	238	238	240	245	= 230
Schultze, Hard, 42grs....	216	221	222	224	230	231	231	238	240	246	= 230
Amberite, No. 2, 42grs...	183	196	211	211	218	220	221	227	227	236	= 215

It will here be observed that, as regards pattern, the black powder records were neither so large nor so regular as those of either of the nitro-compounds. The old and the new samples of Schultze gave practically equal patterns; and Amberite ran them pretty close for the most part, but the results were not quite so regular, there being a wider variation between the highest and the lowest rounds in the Amberite series.

In regard to velocity, however, the black powder showed the greatest regularity from round to round; but, as is usually the case, the recoil with this explosive was much higher than with the nitros, as will be seen by the following records:

MEAN VELOCITY for 40 yards, with RECOIL taken simultaneously.

		Feet per second, and foot-pounds.					Averages.
C. & H. No. 4, 32grs. and 1¼oz. shot	Velocity	817	821	821	824	824	= 821 ft.sec.
	Recoil ...	*32·7*	*32·7*	*32·6*	*32·5*	*32·7*	= *32·6 ft.lb.*
Schultze, Old, 42grs. and 1¼oz. shot	Velocity	792	803	837	837	843	= 822 ft.sec.
	Recoil ...	*23·2*	*23·2*	*26·0*	*24·8*	*25·0*	= *24·2 ft.lb.*
Schultze, Hard, 42grs. and 1¼oz. shot	Velocity	798	838	843	845	848	= 832 ft.sec.
	Recoil ...	*23·0*	*25·7*	*26·7*	*26·0*	*26·5*	= *25·6 ft.lb.*
Amberite No. 2, 42grs. and 1¼oz. shot	Velocity	832	838	843	850	854	= 843 ft.sec.
	Recoil ...	*28·0*	*28·6*	*28·0*	*27·1*	*27·7*	= *27·9 ft.lb.*

We also tested the powders by crusher-gauge, for the purpose of ascertaining the amount of strain in the barrel with the respective explosives. The pressures with the undried powders were lower than usual, owing to the very wet weather which prevailed at the time of these trials. As is ordinarily the case when powders are tested in their normal condition, the black gave more strain than the nitros. The records of the respective rounds were as follows:

CRUSHER-GAUGE RECORDS OF POWDERS IN NORMAL CONDITION.

	Tons per square inch.						Averages.
C. & H. No. 4, 32grs.....	1·83	1·92	1·92	2·08	2·24	2·24	= 2·04
Schultze, Old, 42grs.....	1·29	1·29	1·68	1·73	1·83	1·88	= 1·62
Schultze, Hard, 42grs.....	0·82	1·08	1·29	1·29	1·58	1·58	= 1·27
Amberite No. 2, 42grs.	1·29	1·53	1·58	1·92	2·46	3·00	= 1·96

We also tested the four powders after having submitted them to a drying test at the temperature of 120° Fahr., continued for twelve hours. This we considered preferable to the method adopted at previous trials, of submitting them to a heat test of 212° for ten minutes, as the powders would be more likely to be in a condition of dryness similar to that which might result from keeping cartridges in hot closets, or in tropical climates, and yet would not run the risk of undergoing any such chemical change as might possibly result from being submitted to the temperature of boiling water. After being subjected to the above-mentioned test, the pressures recorded by the respective powders were as follows:

CRUSHER-GAUGE RECORDS OF POWDERS DRIED AT 120° FAHR.

	Tons per square inch.						Averages.
C. & H. No. 4, 32grs.	2·20	2·20	2·24	2·24	2·28	2·28	= 2·24
Schultze, Old, 42grs.	3·42	3·50	3·84	3·90	4·10	4·26	= 3·84
Schultze, Hard, 42grs.....	3·08	3·10	3·10	3·14	3·26	3·36	= 3·17
Amberite No. 2, 42grs.	3·40	3·50	3·54	3·54	3·90	3·98	= 3·64

Black powder, as usual, was not so much affected as nitros by the drying process. The new hard-grained Schultze showed considerably lower strain than the old variety of the same powder, and also less variation from round to round. Amberite No. 2 was likewise less affected than the old sample of Schultze, but more so than the new hard-grained variety. The highest of these pressures, however, is considerably less than that of the proof-charge for 12-bore guns. Amberite No. 1 we could not test in comparison with No. 2, as we had exhausted our stock of the former in previous trials; but the omission is immaterial, as Amberite No. 1 is no longer on sale. We may add that we believe the old variety of Schultze will not be issued in future, but will be superseded by the new hard-grain Schultze.

The damp test to which the powders were submitted was a severe one, as they were exposed to the air, in open saucers, on a wet clay soil throughout the night, but sufficiently under cover to prevent the rain falling on them. The cartridges were loaded next morning after fourteen hours' exposure to the damp; and the records given were as follows:

CRUSHER-GAUGE RECORDS OF POWDERS IN DAMP CONDITION.

	Tons per square inch.						Averages.
C. & H. No. 4, 32grs.....	1·73	1·78	1·83	1·83	1·88	2·04	= 1·85
Schultze, Old, 42grs.....	0·58	0·58	0·71	0·71	0·82	0·91	= 0·72
Schultze, Hard, 42grs.....	0·58	0·58	0·71	0·71	0·71	0·82	= 0·68
Amberite No. 2, 42grs.....	0·71	0·71	0·82	0·82	0·91	0·91	= 0·81

On the whole it may be said that both the new samples gave very satisfactory results; and each is, in our opinion, a decided improvement on the previous powders issued from the same manufactories. The new Schultze is especially noticeable for its smoothness and hardness of grain, as compared with the old variety. On examination through a magnifying glass, the grains appear quite smooth and without any loose fibres, so that they are not liable to clog the cartridge-loading machine; and the grains are also very regular in size, and free from dust.

TRIALS OF NEW POWDERS FOR SHOT GUNS.

(*Field*, Jan. 5, 1895; Vol. 85, p. 10.)

BALLISTITE.

A NEW variety of sporting gunpowder, of the nitro-compound type, is made by Nobel's Explosives Company, 149, West George-street, Glasgow, and Ardeer Factory, Ayrshire. It is composed chiefly of nitro-cellulose, or guncotton, with a small admixture of nitro-glycerine; and with many persons there is a strong prejudice against powders of this class, owing to a belief that they are very susceptible to atmospheric changes; but we must frankly confess that we have been greatly surprised by the extremely small amount of variation produced in the Ballistite powder by the means applied for testing the effects of heat and moisture.

The charge of Ballistite originally prescribed by the makers, as the equivalent for 3drs. of black powder, was 30grs.; and this we used with 1¼oz. of No. 6 shot, in our first experiments with the crusher-gauge. Six rounds were fired with the powder in its normal condition; six more rounds were tried with powder which had been submitted for twelve hours to a constant temperature of 120° Fahr.; and six more, loaded with powder which had been fully exposed for twelve hours to the damp night air, with only such an amount of shelter as would prevent rain falling on the powder. The results of the three trials are shown in the following records:

	Pressure in Tons per square inch.					Averages.
Powder in normal condition (30grs.)	1·83	1·96	2·00	2·04	2·24	2·34 = 2·07
After drying for 12 hours at 120degs. Fahr.....	1·58	1·92	2·16	2·20	2·20	2·34 = 2·07
After 12 hours' exposure to damp	1·68	1·88	2·00	2·04	2·20	2·20 = 2·00

The results of the trials, with the same charge, for velocity (mean of 40 yards), recoil, and pattern (taken simultaneously) were as follows:

Powder in normal condition (30grs.)	Velocity	759	765	771	772	787	793	= 775 ft. sec.
	Recoil ...	*21·8*	*22·1*	*20·5*	*22·0*	*22·3*	*23·0*	= *22·0 ft. lb.*
	Pattern.	210	187	217	214	211	226	= 211 patt.
After 12 hours' exposure to damp ...	Velocity	744	769	770	772	780	785	= 770 ft. sec.
	Recoil ...	*19·4*	*21·7*	*22·0*	*21·5*	*21·4*	*23·5*	= *21·6 ft. lb.*

We did not think it requisite to try the dried powder at the target, as the pressure in the barrel being practically unaltered, there was no probability of change in other respects. We tested the damped powder, however, for velocity and recoil, and for all practical purposes the results were the same as before, the reduction in velocity being less than 1 per cent.

None of the above-mentioned velocities, however, were up to the standard (850ft. per second) adopted in our previous comparative trials of black and nitro-compound powders; and we therefore thought it desirable to carry out some further trials, at 40 yards, for the purpose of ascertaining what increase of charge would be required to bring up the velocity to 850f.s. The results of this supplementary trial are shown in the following table:

Powder in normal condition (33grs.)	Velocity	846	849	849	850	855	858	= 851 ft. sec.
	Recoil ...	*24·9*	*25·0*	*25·1*	*25·0*	*25·4*	*26·0*	= *25·2 ft. lb.*
	Pattern.	200	203	200	189	218	206	= 203 patt.

Thus, 3grs. more of powder were required to raise the velocity to 850 f.s.; this caused a little increase of recoil, and a slight decrease of pattern.

In our previous trials of explosives (see *ante.*, p. 39, *et seq.*) we had tested the pressures in the barrel with 3drs. of black powders, and the equivalent charges of nitro-compounds, and also tried the effects

produced by gradually increasing the charges by three gradations of about 10 per cent. each. We followed the same course with Ballistite, and the results exhibited by the three increases were as follows:

	Pressures in Tons per square inch.					Averages.
First increase to 33grs....	2·37	2·37	2·40	2·43	2·43	2·49 = 2·42
Second " " 36grs....	2·61	2·76	2·94	3·00	3·02	3·06 = 2·90
Third " " 39grs....	2·85	2·91	3·22	3·36	3·55	3·82 = 3·29

The third increase (39grs.) was the largest charge which could be used in the special cartridge cases made by Messrs. Eley for the Ballistite powder—the wadding being that which we usually employ, viz., first, a thin card, then a ¼in. soft felt, followed by a grey cloth wad, and another thin card over the shot. These special cases have a cup-shaped base, similar to the foreign cartridge cases reported on last year; but they have not the long-legged anvil employed in the foreign cases. The Nobel Company prefer that the special case should be used with their powder, as it limits the amount of the explosive which can be placed in the cartridge.

In order to ascertain what would be the effect of a careless loader using very excessive charges of Ballistite in the ordinary flat-based cartridge cases, we tried three further increases of charge; and we found that, with 42grs. the average pressure was 3·93 tons; with 45grs. it was 4·16 tons; and with 48grs. it rose to 4·77 tons.

Subsequently we put the powder to another heat test, viz.. that of submitting it to the temperature of 212° Fahr. for ten minutes. We found that 33grs. of Ballistite, in its normal condition, gave a pressure of 2·42 tons; and a similar charge, after being submitted to a temperature of 212°, gave a pressure of 2·82 tons.

Altogether, we consider that the results of these trials were very satisfactory; and we may conclude by saying that we look upon this Ballistite powder as a valuable addition to the list of sporting explosives.

(*Field*, Jan. 18, 1896; Vol. 87, p. 98.)

MESSRS. NOBEL have recently made an alteration in the form of their Sporting Ballistite, the flakes being now much thinner and larger than they were formerly. But it should be distinctly understood that this is the only difference between the old and the new powder; the chemical constituents are precisely the same.

About a year ago we made an exhaustive trial of the old form of Ballistite, and obtained excellent results. But, in consequence of the thickness of the flakes, the whole of the powder was not consumed in the barrel, and occasionally the residue was found to interfere with the proper working of the breech action. The recent alteration has not only entirely removed this defect, but, on account of the more complete combustion, 26grs. of the new powder has been found to be superior in ballistic effect to 30grs. of the old powder.

In the trials which we have now carried out, the charge used throughout was 26grs. of Ballistite and 1⅛oz. of No 6 shot, and the wadding was as follows: Black and pink card over the powder, then a ¼in. soft felt and a thick card, and a thin card over the shot.

The cartridge cases used were made by leading manufacturers, and are designated by the numbers 1 and 2. They were supplied to us by the Nobel Company, who do not wish any invidious comparison to be made between the respective makers, and therefore the names are withheld from publication.

The trials for velocity (mean of 40yds.), recoil, and pattern were taken simultaneously. Those for pressure in the gun chamber were taken separately, and were as follows:

No. 1 CASES.

	Pressure in Tons per sq. inch.					Averages.
Powder in normal condition ...	2·40	2·43	2·76	2·58	2·37	2·52 = 2·51
After drying for twelve hours at 120° Fahr.	2·37	2·34	2·70	2·43	2·73	2·61 = 2·53
After twelve hours' exposure to damp.....	2·46	2.46	2·43	2·28	2·31	2·24 = 2·36

		Velocity, Recoil, and Pattern.						Averages.
Powder in normal condition.	Velocity.....	815	801	824	821	830	826	= 819 ft. sec.
	Recoil	*26·1*	*24·8*	*25·3*	*26·0*	*26·7*	*26·1*	= *25·8 ft.lb.*
	Pattern	178	212	198	231	227	190	= 204 patt.

It was not thought necessary to again test the power in the heated and damped conditions, as no practical differences resulted therefrom.

No. 2 CASES.

Pressure in Tons per sq. inch.					Averages.
2·34 ...	1·92 ...	2·31 ...	2·00 ...	2·16 ...	1.92 = 2·11

	Velocity, Recoil, and Pattern.					Averages.
Velocity	798 ...	798 ...	808 ...	811 ...	798	810 = 802 ft. sec.
Recoil	*23·5* ...	*24·7* ...	*25·0* ...	*25·2* ...	*24·5*	*25·0* = *24·7 ft. lb.*
Pattern.....	186 ...	200 ...	218 ...	197 ...	230	231 = 209 patt.

In conclusion we may say that, in our opinion, Messrs. Nobel may fairly be congratulated on the excellent results obtained with their new form of Sporting Ballistite.

HALL'S SMOKELESS SAFETY POWDER.

CANNONITE.

(*Field*, March 9, 1895; Vol. 85, p. 289.)

A NEW nitro powder called Cannonite has recently been submitted to us for trial by Messrs. Hall and Sons, of Cannon Street, the well-known makers of black powders.

On this occasion we have used No. 4 T.S. black powder as the only standard of comparison, and we would take this opportunity of drawing attention to the effect of the recent very severe weather on so reliable an explosive as black powder. The black powder used in this trial was taken from the same bottle as that used in some trials we carried out last autumn. The cartridge cases and wads were also of the same make, and yet there occurred a falling off of 17ft. per second (from 850 to 833 ft.sec.) in the mean velocity in 40 yards. We have no doubt that the weather also prejudicially affected the records obtained with Cannonite powder; but the manufacturers preferred having the trial made at once rather than wait for more favourable weather.

1⅛oz. of No. 6 shot, and wadding as follows, were used throughout the trial: A thin card next the powder, then a ¼in. soft felt, followed by a grey cloth wad, and a thin card over the shot. Other kinds of wadding were tried, but the above gave the best results. Messrs. Eley's cartridge cases were used throughout—special ones (with conical bases and exceedingly large flash-holes) being used for the Cannonite powder, and ordinary cases for the black powder.

The unusually large flash-holes in the Cannonite cases we believe to be a new departure in cartridge manufacture; and it probably may have an important influence on the use of nitro powders, especially those that are very fine in the grain. It has always been difficult to prevent dust-like grains from finding their way into the interior of the cap, and thus producing "blow-backs." Here the crown of the dome is so cut away that, instead of a small flash-hole, the opening is nearly as large as the interior of the cap. Consequently the powder can enter freely into the cap, and, when it is ignited, the gases can pass unchecked into the body of the cartridge, instead of being so closely confined as possibly to drive back the cap and cause a jamb.

We append the results of the trial of pressure in tabular form:—

POWDERS IN NORMAL CONDITION.

	Tons per square inch.					Average.
BLACK, 82grs.	2·00	2·00	2·08	2·12	2·16	2·20 = 2·09
CANNONITE, 37grs.....	1·15	1·15	1·22	1·22	1·29	1·41 = 1·24
" 39grs.....	1·63	1·68	1·68	1·73	2·00	2·24 = 1·83
" 42grs.....	1·63	1·68	1·68	1·73	2·31	2·37 = 1·90
" 45grs.....	1·68	1·78	2·04	2·08	2·28	2·28 = 2·02

It will be noticed that we have tried several charges of Cannonite powder, from 37grs. to 45grs., in order to show the effect of overloading. The manufacturers recommend the charge of 35grs.; but we have found it necessary to increase the charge to 37grs., in order to bring up the velocity to that given by 3drs. of black powder, although 35grs. may be sufficient under more favourable conditions of weather.

It will be seen, however, that the charge may be increased considerably without greatly affecting the pressure developed. When raised to 45grs. the pressure was rather lower than with the ordinary 3drs. charge of black powder.

The Cannonite powder is very little affected by heat or damp. After drying for twelve hours (at 120° Fahr.) the pressures increased to little more than that exhibited by 3drs. of undried black powder.

	Tons per square inch.					Average.
CANNONITE, 37grs.....	2·00	2·08	2·12	2·16	2·16	2·24 = 2·13

After twelve hours' exposure to damp, the pressures were as follows:

	Tons per square inch.					Average.
CANNONITE, 37grs.....	1·00	1·00	1·08	1·08	1·15	1·22 = 1·09

Hence the twelve hours' exposure to damp only reduced the pressure from 1·24 tons to 1·09 tons.

The records for velocity (40 yards range), recoil, and pattern, with both powders in their normal condition, were as follows:

							Average.
BLACK, 82grs.	Velocity...	824	838	835	835	838	838 = 833 ft.sec.
	Recoil	*32·0*	*33·0*	*33·3*	*33·0*	*33·3*	*33·5* = *33·0 ft.lb.*
	Pattern ...	168	168	173	175	188	197 = 177 patt.
CANNONITE, 37grs...	Velocity...	828	830	830	836	840	845 = 835 ft.sec.
	Recoil	*27·0*	*27·5*	*28·0*	*28·0*	*27·3*	*28·5* = *27·7 ft.lb.*
	Pattern ...	199	196	205	207	214	214 = 204 patt.

In conclusion, we may say that Cannonite is a powder of the concentrated type, occupying very little space in the cartridge case; and it appears to us probable that powders of this class are likely to be more generally adopted.

CANNONITE POWDER (COARSE AND FINE GRAIN).

(*Field*, Dec. 18, 1897; Vol. 90, p. 977.)

We have received from Messrs John Hall and Son, of Cannon-street, samples of their Cannonite powder in the two forms now made for use in shot guns—one of which is coarse in grain, has the same bulk as No 4 black powder, and may be loaded in any case ordinarily used for the more bulky nitro-compounds; while the other is fine in grain, and should be used in cone-base cases.

TRIAL OF COARSE GRAIN CANNONITE.

(Barometer, 29·21in.; Thermometer—Wet bulb, 44°; Dry, 44°).

12-Bore Gun; weight 7lb.; barrels, 30in. Powder, 42grs. by weight, or 3drs. by measure; shot, 1⅛oz. No. 6 (304 pellets). Wads, thin card, ⅛in. felt, grey cloth, thin card over shot; Eley's cheap E.B. cases. Gas pressure—average 2·49 tons per sq. inch; highest round, 3·00; lowest, 2·04 tons.

CHOKE BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10yds.) Ft. sec.	Recoil. Ft. lb.
1	78	68	44	35	20	13	290	84	1172	27·5
2	88	75	36	32	14	16	231	73	1154	26·9
3	70	51	43	26	23	14	190	114	1136	26·8
4	92	71	37	31	18	11	231	73	1163	27·0
5	68	58	48	30	21	20	204	100	1119	25·7
6	85	65	42	31	22	15	233	81	1132	26·3
7	89	70	38	27	19	12	224	80	1200	28·8
8	78	62	45	34	22	16	219	85	1124	26·0
9	50	64	37	32	20	14	183	121	1158	27·2
10	99	58	40	38	12	10	235	69	1148	26·7
Average	79	64	41	32	19	14	216	88	1151	26·9

The diameter of the 1st ring is 15 inches; area 225 circular inches.
" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36¾ "
} The area of each belt, between two rings, is the same as above.

REMARKS.—This appears to be an excellent powder, and it gave scarcely any smoke or residue. The patterns were unusually high, there being only two rounds out of ten with less than 200 pellets. With the same barrel of the same gun, the patterns seldom average much more than 190 with nitro powders.

The individual pressures in ten rounds, of the coarse-grain powder, in its ordinary condition, were as follows:

Pressures in Tons per square inch. Average.
2·04 2·82 2·55 3·00 2·31 2·97 2·28 2·40 2·31 2·24 = 2·49

We afterwards tested a similar number of cartridges after exposure to heat and damp. The velocity and recoil were taken simultaneously; the crusher-gauge pressures are taken separately. The results are as follows:

After drying for twelve hours at 120° Fahr. Average.
Velocity: 1172, 1136, 1124, 1172, 1145, 1176, 1181, 1154, 1163, 1141 = 1156 ft. sec.
Recoil: 27·5, 25·7, 25·5, 27·0, 25·5, 27·1, 27·8, 26·0, 26·7, 25·4 = 26·4 ft. lb.
Pressure: 2·85, 3·00, 2·76, 2·91, 2·76, 3·06, 3·12, 2·88, 2·94, 3·10 = 2·94 tons.

After twelve hours' exposure to damp. Average.
Velocity: 1115, 1136, 1141, 1111, 1124, 1136, 1124, 1132, 1119, 1128 = 1127 ft. sec.
Recoil: 23·6, 25·0, 25·6, 24·0, 24·1, 25·0, 24·2, 24·7, 23·8, 24·2 = 24·4 ft. lb.
Pressure: 2·20, 2·34, 2·12, 2·06, 2·28, 2·04, 2·16, 2·31, 2·16, 2·31 = 2·20 tons.

TRIAL OF FINE GRAIN CANNONITE.

(Barometer, 29·30in.; Thermometer—Wet bulb, 46°; Dry, 46°).

12-Bore Gun; weight, 7lb.; barrels, 30in. Powder, 35grs.; shot, 1⅛oz. No. 6 (304 pellets). Wads, thin card, ⅛in. felt, grey cloth, thin card over shot, Eley cases. Gas pressure—average 2·98 tons per sq. inch; highest round, 3·30; lowest, 2·70 tons.

CHOKE BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10yds.) Ft. sec.	Recoil. Ft. lb.
1	68	46	32	22	19	9	168	136	1163	26·2
2	89	48	49	23	21	14	209	95	1186	28·1
3	76	53	46	26	26	15	201	103	1190	28·8
4	81	46	40	25	17	11	192	112	1167	26·7
5	75	50	47	23	21	16	195	109	1172	27·4
6	85	53	43	25	15	13	206	98	1148	25·8
7	87	50	38	20	17	17	195	109	1190	27·9
8	65	49	43	23	19	20	180	124	1172	27·5
9	76	55	45	27	20	18	203	101	1235	29·7
10	78	48	32	22	22	22	175	129	1167	26·9
Average	78	49	41	24	20	16	192	112	1179	27·5

REMARKS.—Velocity and pattern very good. The average pattern was 24 pellets less than with the coarse grain; but velocity, recoil, and stress in the barrel were rather higher. This powder must be used in cone-base cases.

The individual pressures in ten rounds of the fine-grain powder, in its ordinary condition, were as follows:

Pressures in Tons per square inch. Average.
3·30 2·94 3·30 2·73 2·88 3·04 2·70 2·88 2·91 3·12 = 2·98

When tested after exposure to heat and damp, the results obtained were as follows:

After drying for twelve hours at 120° Fahr. Average.
Velocity: 1235, 1176, 1235, 1154, 1154, 1200, 1186, 1163, 1225, 1158 = 1189 ft. sec.
Recoil: 28·5, 26·9, 27·7, 26·0, 26·2, 27·6, 27·4, 26·6, 28·0, 26·5 = 27·1 ft. lb.
Pressure: 3·20, 2·76, 3·66, 2·67, 3·54, 2·85, 3·60, 3·10, 3·42, 2·94 = 3·17 tons.

After twelve hours' exposure to damp. Average.
Velocity: 1163, 1163, 1154, 1163, 1149, 1163, 1172, 1158, 1167, 1149 = 1160 ft. sec.
Recoil: 25·0, 25·5, 25·1, 25·9, 25·4, 26·0, 26·3, 25·0, 26·4, 24·9 = 25·6 ft. lb.
Pressure: 2·04, 2·12, 1·88, 2·04, 1·88, 2·00, 2·16, 2·08, 1·92, 2·20 = 2·03 tons.

It will be observed that, with both kinds of powder, there was some little increase of velocity, recoil, and pressure, when the powder was dried, and some diminution when it had been exposed to damp; but the differences were too small to be of any practical importance.

The conclusion we draw from the above facts is, that the coarse-grain powder will suit best with barrels which, like some cylinder guns, unduly scatter the shot-charge; whereas the fine-grain powder will best suit those choked barrels which make too close a pattern. The coarse grain also possesses an advantage over the fine grain, viz., that it cannot get into the cap and cause "blow-backs."

SHOT-GUN RIFLEITE.

(*Field*, July 4, 1896; Vol. 88, p. 3.)

A NEW smokeless powder, which has been given the curious name of "Shot-gun Rifleite," has recently found its way into the market. It it is a concentrated powder of the leaflet type, is silver-grey in colour, and possesses a beautiful metallic lustre. This powder is manufactured by the Smokeless Powder Company Ltd., and made on the assumption that for a given propelling power the bulk should be the same as that of No. 4 Black.

There is every probability that, in course of time, these concentrated powders will be almost universally employed; until, in their turn, they may be supplanted by something better. We have heard that other manufacturers of nitro-compounds have concentrated varieties "on the stocks," in readiness to launch whenever the public demand for them becomes sufficiently great to warrant the taking of such a step. The principal advantages of the concentrated powders are: the almost entire absence of smoke, and of the gritty, irritating particles which frequently seriously affect the eyes of the shooter; the very small deposit left in the barrel after firing; and, more important than all, their immunity from excessive change of explosive force arising from atmospheric influences.

By consulting the appended table it will be seen that, although the "Shot-gun Rifleite" was exposed to damp for twelve hours, the velocities and pressures were practically unaffected. And after it had been dried for twelve hours at a temperature of 120° Fahrenheit the highest pressure recorded in ten rounds was under 3 tons. This is a moderate pressure for a powder which has undergone so severe an ordeal, and is still well below the pressure of the proof-charge with the ordinary coarse-grain powder, as that amounts to about 4½ tons.

The velocities, recoil, and pressures, with the powder in its normal condition, and after twelve hours' exposure to damp, are here given, together with the pressures only after the normal sample had been dried for twelve hours.

In the Normal State.			After Damping.			Dried.
Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.	Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.	Pressure. Tons.
1195	29·0	1·53	1176	28·1	1·29	2·97
1186	28·9	1·63	1154	27·0	1·63	2·24
1163	28·0	1·73	1172	28·4	1·47	2·94
1158	28·3	1·78	1158	27·9	1·29	2·64
1167	28·0	1·63	1163	28·6	1·53	2·94
1181	29·3	1·58	1181	28·6	1·41	2·61
1141	27·3	1·68	1133	26·5	1·68	2·55
1149	28·5	1·63	1172	28·1	1·35	2·73
1190	29·1	1·73	1149	27·3	1·41	2·67
1176	28·6	1·58	1167	28·5	1·53	2·62
1171	28·5	1·67	1162	27·9	1·46	2·71

The patterns with the powder in its normal condition were as follows:

(Barometer, 29·70; Thermometer—Dry 69°, Wet 60°.)

12-Bore, Left Barrel.—Charge of powder, 37grs.; shot, 1⅛oz. No. 6 (304 pellets); wadding, thick card, ⅛in. felt, thick card, and another thick card over the shot; Joyce's maroon cone-base cartridge cases; turnover ½in.

	40 YARDS PATTERN.						Total	
Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	in 30in. circle.	Outside 30in.
1	70	70	38	28	15	15	206	98
2	72	48	42	28	26	20	190	114
3	65	51	41	40	24	14	197	107
4	91	61	39	30	17	16	221	83
5	83	59	42	27	19	13	211	93
6	76	66	35	30	21	11	207	97
7	62	46	43	28	35	9	179	125
8	88	57	40	32	20	16	217	87
9	105	64	33	28	18	12	230	74
10	21	16	21	18	17	15	76	228
Average	73	54	37	29	21	14	193	111

The patterns were good and fairly regular with the exception of the last shot. It would have been easy to expunge the last pattern and fire another cartridge, but we thought it better to publish the results exactly as they were obtained. It is a most curious circumstance—and one which we frankly admit we cannot account for, unless it be due to variations in the caps—that with the very best materials, the most careful loading and aiming, there occasionally occur poor patterns similar to this. No wonder we sometimes hear a sportsman remark, after missing, "I could have sworn I was dead on that bird."

TRIAL OF NORMAL SHOT-GUN POWDER.

(*Field*, Oct. 17, 1896; Vol. 88, p. 612.)

At the request of the Normal Powder Syndicate Limited we recently made a trial of their new sporting powder, which has been manufactured specially for use in shot guns. This powder is one of the concentrated type, although the concentration is not carried to so great an extent as it is in some of the new powders.

By referring to the records tabulated below it will be noticed that it is slightly more affected by heat than some of the other concentrated powders, though not to the same extent as the older and bulkier kinds. Its damp-resisting qualities are exceedingly good. Our usual damp test is to expose the powder to the action of damp air for twelve hours; but in this instance, by the request of the powder manufacturers, it was placed under water for six hours, and afterwards rubbed between sheets of blotting paper to absorb the superfluous moisture before being loaded into the cartridge cases.

The following are records, taken by crusher-gauge, of the pressures given by this powder in three conditions, viz.: (A) its ordinary state, (B) after being dried for twelve hours at a temperature of 120° Fahrenheit, and (C) after having been placed under water for six hours and then dried by means of blotting paper.

	Pressures in Tons per square inch.									Average.
(A)	2·31	2·28	2·52	2·73	2·34	2·46	2·55	2·31	2·40	2·49 = 2·44
(B)	3·34	3·36	3·42	3·38	3·52	3·44	3·34	3·48	3·30	3·42 = 3·40
(C)	2·20	2·31	2·08	2·28	2·00	2·24	2·34	2·12	2·24	2·20 = 2·20

The records of pattern, velocities and recoil, when fired from a 12-bore rather full choke gun of 7lb. weight, were as follows:

(Barometer 29·45 inches; Thermometer—Dry 45°, Wet 45°.)

	40 YARDS PATTERN.						Total	Out-	Velocity	
	1st	2nd	3rd	4th	5th	6th	in 30in.	side	(10 yards).	Recoil.
Round.	ring.	ring.	ring.	ring.	ring.	ring.	circle.	30in.	Ft.sec.	Ft.lb.
1	81	55	41	31	17	17	208	96	1167	24·5
2	75	53	40	29	19	20	197	107	1172	25·0
3	91	57	27	35	20	15	210	94	1163	24·8
4	80	45	40	30	18	17	195	109	1149	23·5
5	83	56	37	28	21	19	203	101	1172	25·0
6	88	57	39	30	21	18	214	90	1154	24·0
7	76	48	22	23	16	27	164	140	1181	25·3
8	83	55	30	27	18	20	195	109	1145	24·0
9	76	56	41	27	17	21	200	104	1176	25·2
10	68	49	43	27	21	23	187	117	1158	24·4
Aver.	80	58	36	29	19	20	197	107	1164	24·6

Joyce's cone-base cartridge-cases were used, with 32grs. of Normal powder and 1⅛oz of No. 6 hard shot. The wads were—first, a thin card, then ⅛in. felt, grey cloth, and card over the shot.

It will also be noticed that the patterns are well up to the average, the recoils rather low, and velocities good and regular.

After the powder had been six hours under water, and then merely dried by means of blotting-paper, the velocity and recoil of ten rounds were as follows:

Velocity in feet per second, and Recoil in foot-pounds.										Averages.
Velocity	1158	1163	1141	1154	1167	1158	1172	1149	1163	1141 = 1157
Recoil	*24·0*	*24·5*	*23·0*	*24·2*	*24·8*	*24·1*	*25·2*	*23·5*	*24·6*	*23·4 = 24·1*

Practically speaking, the records are as good with the powder after passing through this ordeal as they are with the powder in its ordinary condition, showing conclusively that it is thoroughly waterproof. We may also add that the powder leaves practically no deposit in the barrel.

(*Field*, Jan. 16, 1897; Vol. 89, p. 70.)

In order to meet the demand for a cheaper cartridge than that usually used, the Normal Powder Syndicate Limited have lately loaded, with their powder, a quantity of low-priced cases; but before issuing them to the public they requested us to make a trial, and we here subjoin the results, which, in our opinion, are very good.

(Barometer, 29·37; Thermometer—Dry 43°, Wet 43°.)

12-Bore Gun; weight 7lb.; barrels 30in. Charge of powder, 32grs.; shot, 1⅛oz. (304 pellets) No. 6. Wadding as follows: Waterproof card, ⅛in. felt, thin feltine wad, and thick card over shot. Gas pressure, average 2·43 tons per square inch (highest 2·64, lowest 2·20 tons). Left choked barrel only used.

	40 YARDS PATTERN.						Total	Out-		
	1st	2nd	3rd	4th	5th	6th	in 30in.	side	Velocity.	Recoil.
Round.	ring.	ring.	ring.	ring.	ring.	ring.	circle.	30in.	Ft. sec.	Ft. lb.
1	72	41	33	22	18	19	168	136	1186	26·8
2	84	53	35	28	23	22	200	104	1181	27·2
3	68	44	38	23	16	23	173	131	1154	24·1
4	70	49	33	29	24	21	181	123	1172	26·7
5	75	40	31	23	20	18	169	135	1200	29·5
6	62	48	42	28	25	22	180	124	1176	24·0
7	81	51	39	30	26	19	201	103	1190	27·5
8	78	42	35	21	23	20	176	128	1163	26·3
9	61	55	40	21	17	17	182	122	1172	27·0
10	73	50	36	25	20	17	184	120	1181	26·1
Aver.	72	47	36	26	21	20	181	123	1178	26·5

BLACK POWDER CARTRIDGES (DIAMOND GRAIN No. 2).

(*Field*, Dec. 4, 1897, Vol. 90, p. 876.)

Sir,—We have noticed your recent articles and remarks on nitro-compounds, and, as there are still many sportsmen who continue to use black powder, and among the number who do so are some notable shots, we take the liberty of sending you a sample of our improved Diamond Grain cartridges, as advertised.

The improvement meant is in the proportions of charge, suitable wads, and careful loading, which have been arrived at after many experiments. We are convinced that much of the abuse heaped on black powder has been caused by overloading, people generally taking at least 3drs., and often more, quite irrespective of the quality of the powder and size of grain.

We have therefore chosen our Diamond No. 2 for these cartridges, and find that 2½drs. (or slightly less) with 1oz. shot gives shooting, both at the target and in the field, that leaves little to be desired—except, of course, that there is a certain amount of smoke; though, naturally, with this small charge of a fine grain and good quality powder, the amount is very much less than what is commonly seen in the cheap cartridges that are on the market. In the open, the small quantity of smoke is no impediment to satisfactory shooting; and we have constant testimony of this, and the fact of Lord Walsingham's large bag of grouse having been made with black powder, and a much heavier charge than we use, is direct evidence of this.

In the covert, where rapid shooting is going on, it is, of course, different, but we have noticed that some of the nitro powders are very little better in this respect.

London, E.C., Nov. 23, 1897. Curtis's and Harvey.

[We received from Messrs Curtis's and Harvey a parcel of cartridges loaded with their No. 2 Diamond Grain powder, as alluded to in the foregoing letter. We have tested them in accordance with their request, and herewith give the results in tabular form.

Sixty-eight grains of Curtis's and Harvey's No. 2 Diamond Grain powder, with 1oz. (270 pellets) of No. 6 shot. Wads: thick waterproof card, ½inch felt, two thick cards, thin card over shot; Messrs Curtis's and Harvey's own loading; 12-bore gun, weight 7lb. Right barrel, cylinder; left, choke. The mean velocities in 10 yards range are given.

Round.	40 yards Pattern, Right Barrel.								Velocity (10yds.) Ft. sec.	Recoil. Ft. lb.
	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30 inches.		
1	38	31	26	22	20	16	117	153	1205	27·7
2	29	28	20	19	9	10	96	174	1200	27·1
3	33	19	32	27	10	16	110	160	1205	27·8
4	40	32	26	20	23	12	118	152	1230	27·9
5	26	27	28	23	10	15	104	166	1230	28·2
6	39	27	35	18	10	11	109	161	1230	28·1
7	28	26	23	22	16	18	99	171	1210	27·4
8	32	34	26	25	20	19	117	153	1240	29·0
9	37	29	27	28	18	12	121	149	1220	27·6
10	36	33	30	27	22	17	125	145	1210	27·3
Average	34	29	26	23	16	15	112	158	1218	27·8

Round.	40 yards Pattern, Left Barrel.								
	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30 inches.	
1	62	38	30	22	22	20	152	118	Velocity and Recoil (as above).
2	60	42	36	26	18	14	164	106	
3	62	46	36	27	20	11	171	99	
4	71	44	34	24	14	15	173	97	
5	55	38	43	30	16	9	156	114	
6	52	45	23	34	26	20	154	116	
7	65	35	31	26	17	13	157	113	
8	52	37	26	26	14	23	143	127	
9	70	41	35	23	22	19	169	101	
10	67	48	30	21	13	11	166	104	
Average	62	41	32	25	18	16	160	110	

We also tested ten rounds with the crusher-gauge, and the pressures were as follows:

Tons per square inch.									Average.
2·73	2·76	2·76	2·64	2·55	2·73	2·67	2·73	2·58	2·61 = 2·68 tons.

The above results are eminently satisfactory; and, in our opinion, still better results would be obtained with a smaller charge of the same powder. We would suggest 60grs., as it will be noticed that the velocities are very high—averaging as they do about 60 ft.sec. above our ordinary standard.

As showing the close connection between velocity and recoil, we may mention that the difference in velocity between the highest and lowest rounds was a little under 3½ per cent. (and that, no doubt, was mainly due to some variation in strength of the caps). With recoil, the amount varies as the "square" of the velocity, and consequently the percentage of difference is about doubled. This was just borne out in the present instance, as the highest round gave 7 per cent. more recoil than the lowest. The percentage of difference in the crusher-gauge records was also 7 per cent. One can readily understand, therefore, that those explosives which are more sensitive than black powder is to variations in the igniting force, should occasionally show wider differences in pressure, velocity, and recoil.

The amount of smoke given off by these cartridges is very little, and would be still less with a reduced charge. If Messrs Curtis's and Harvey care to send us some cartridges loaded with a reduced charge of powder, we will test them and publish the results.—Ed.

(*Field*, Jan. 1, 1898; Vol. 91, p. 21.)

In our impression of the 4th of December last we gave particulars of the trial of some cartridges specially loaded by Messrs. Curtis's and Harvey with their Diamond Grain No. 2 powder and 1oz. of No. 6 shot, in 12-bore cases. The charge of powder then used was 68grs. (the nearest equivalent to 2½drs.), and we found the results very good, but the velocity was needlessly high, so we suggested that the charge should be somewhat reduced. This has now been done—not to the extent erroneously stated in our previous impression, but to 66grs., which gives a velocity that is up to our ordinary standard, viz., 1160 feet per second in a 10 yards range—equivalent to a muzzle velocity of about 1220ft.sec. The wads used were first, a Field wad, followed by ½in. felt and cloth wad, with a thin card over the shot. The gun used was our ordinary experimental 12-bore, weighing 7lb., both choke and cylinder barrels being used, and the results obtained were as follows:

(Barometer, 30·03in.; Thermometer—Wet bulb, 33°; Dry, 33°.)

Right Barrel.—40 yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity (10yds.) Ft.sec.	Recoil. Ft.lb.
1	38	32	30	22	22	15	122	148	1158	25·9
2	40	35	29	25	20	18	129	141	1181	26·4
3	33	30	27	27	25	12	116	154	1154	25·6
4	44	36	29	23	19	17	132	138	1172	26·6
5	37	29	25	20	21	16	111	159	1167	26·0
6	39	35	32	26	24	14	132	138	1172	26·2
7	35	37	27	21	18	15	120	150	1163	25·9
8	41	33	26	20	16	11	120	150	1141	25·4
9	32	30	28	22	20	19	113	158	1186	26·7
10	37	35	33	26	22	17	131	139	1149	25·1
Average	38	33	29	23	21	15	123	147	1164	26·0

Left Barrel.—40 yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	
1	68	44	38	30	26	20	180	90	Velocity and Recoil (as above).
2	62	40	32	26	22	15	160	110	
3	70	42	36	24	20	17	172	98	
4	69	50	34	22	18	20	175	95	
5	68	41	31	25	24	12	165	105	
6	57	45	37	33	25	19	172	98	
7	72	46	35	25	21	16	178	92	
8	62	43	36	27	24	18	168	102	
9	76	51	33	24	19	12	183	87	
10	70	48	35	26	25	20	179	91	
Average	67	45	35	26	22	17	173	97	

The diameter of the 1st ring is 15 inches; area 225 circular inches.

"	" 2nd	" 21½	"	The area of each belt, between two rings, is the same as above.
"	" 3rd	" 26	"	
"	" 4th	" 30	"	
"	" 5th	" 33½	"	
"	" 6th	" 36¾	"	

We also tested ten rounds with the crusher-gauge, and the pressures averaged 2·51 tons per square inch—the highest round being 2·64 and the lowest 2·40. For purposes of comparison we give a brief summary of the two trials:

Powder Charge.	Cylinder Pattern.	Choke Pattern.	Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
68grs.	112	160	1218	27·8	2·68
66grs.	123	173	1164	26·0	2·51

It will be observed that, with the reduced charge of powder, the velocity is well up to our standard, while the patterns are higher, and the recoil and stress in the barrel lower than in the former trial. Altogether, the results are very satisfactory.

(*Field*, Jan. 15, 1898; Vol. 91, p. 90.)

IN 16-BORE GUN.

In the previous article (on this page) we gave particulars of a trial we carried out with 12-bore cartridges loaded with 66grs. of No. 2 Diamond-grain powder and 1oz. of No. 6 shot. The results obtained were excellent—velocities being well up to our usual standard (*i.e.*, 1160 feet per second in a range of 10 yards—a standard, it may be mentioned, that was founded on the velocity given by 3drs. of C. & H.

No. 4 T.S. powder with 1⅛oz. of No. 6 shot, in a 12-bore gun), while the patterns were very regular, as well as numerically higher than when more powder was used; besides which, recoil and stress in the barrel were diminished.

Since then we have carried out a series of somewhat similar experiments in a 16-bore gun—a suggestion recently made by "Purple Heather" having been acted on by Messrs Curtis's and Harvey, who forwarded to us for trial four samples of 16-bore cartridges, some of which were loaded with 2½drs. of Diamond-grain No. 2, while the others had but 2drs., and half of them contained 1oz. of No. 6 shot, while the rest had only ¾oz.

It is probable that some of our readers might be inclined to doubt the efficacy of such small charges as ¾oz., and to "pooh-pooh" records obtained at the target were no other evidence forthcoming on the subject. But much additional weight has been added to target records by Sir Frederick Milbank's very interesting letter, published in our last impression—which letter, by a curious coincidence, was written during the very time when our present experiments were being carried out, though our trials were not completed early enough for this article to appear in the *Field* of Jan. 8.

It is evident, from Sir F. Milbank's letter, that small charges of shot are not so recent in origin, nor so futile in their results, as many sportsmen seem to imagine. Small charges of powder, no doubt, were generally used in former days; but the shot charges then used were such as we now should consider excessive. In the early *Field* Gun Trials (carried out in 1858 and 1859), the "new-fangled" breech-loaders of forty years ago were tested in comparison with the muzzle-loaders then in general use—some of which dated back to the days of Joe Manton. The 12-bore muzzle-loaders were almost invariably loaded with 2¾drs. of powder and 1¼oz. of shot, although one light 12-bore of 6lb. 10oz. had its charge reduced to 2½drs. of powder and 1⅛oz. of shot. The breechloaders, however, were generally very heavy, and used 1¼oz. shot with 3drs. of powder—as an extra quarter of a dram was considered requisite in the pinfire cartridge to give as much penetration as was obtainable with the smaller charge in the barrel of the muzzle-loading gun.

Little more than a dozen years later, however, in 1872, we find Sir Frederick (then Mr) Milbank, not merely using 2¾drs. of powder in 12-bore pinfire cases, with only ¾oz. of No. 6 shot, but making the then unprecedented score of 364 brace of grouse in one day; while his record of 190 birds in 23 minutes has never since been equalled by any charge. It becomes obvious, therefore, that there is great potency in ¾oz. of No. 6, when fired from good 12-bore guns by a man who has the requisite ability to use them with full effect. Hence we cannot agree with a correspondent who asserted a fortnight ago (Jan. 1) that "to underload a 12-bore is wasting good powder and shot." And if, as he further alleges, "guns of smaller bore can do the same work, only in a better manner," we can only say that any small-bore guns which will give better results with ¾oz. of No. 6 than the 12-bores alluded to above must have very remarkable men behind them.

However, we have not the slightest intention of disparaging the performances of small-bores. In our own opinion, every man should use whatever guns and loads he may find give him personally the most satisfactory results. And as our present purpose is to show what have been the effects produced by small charges in a 16-bore gun, we will now state the particulars of these trials, commencing with cartridges loaded with 2½drs. and 1oz.:

2½ Drams of Powder and 1oz. of No. 6 Shot, in 16-Bore Gun.

(Barometer, 29·85in.; Thermometer—Wet bulb, 45°; Dry, 45°.)

16-Bore Gun; weight 6lb. 8oz.; barrels, 30in. Powder, 2½drms.; shot, 1oz. No. 6 (270 pellets). Wadding: Thick card, ⅜in. felt, and thick card, with thick card over shot. Gas pressure—average 2·97 tons per sq. inch; highest round, 3·06; lowest, 2·87 tons.

Right Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds). Ft.sec.	Recoil. Ft.lb.
1	33	36	27	17	13	13	112	158	1141	25·0
2	38	24	33	17	18	18	112	158	1149	24·7
3	35	32	29	22	20	16	118	152	1172	25·6
4	34	23	24	23	14	20	103	167	1145	25·7
5	36	33	26	17	18	15	112	158	1163	25·2
6	30	29	29	19	16	17	107	163	1176	24·6
7	40	31	27	21	19	15	119	151	1149	24·3
8	35	27	26	14	18	20	102	168	1167	25·0
9	24	36	22	20	16	14	102	168	1154	24·8
10	33	33	28	23	22	17	117	153	1173	25·3
Average	34	30	27	19	17	16	110	160	1159	25·0

Left Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	
1	42	28	26	21	21	19	117	153	
2	55	49	37	29	23	11	170	100	
3	61	46	41	27	14	20	175	95	Velocity and Recoil (as before).
4	27	30	30	22	18	19	99	171	
5	64	38	43	33	18	20	177	93	
6	52	42	36	30	21	17	160	110	
7	67	48	33	25	17	16	173	97	
8	65	45	30	28	22	13	168	102	
9	60	39	37	24	20	19	160	110	
10	58	43	25	36	22	20	162	108	
Average	55	40	34	27	20	17	156	114	

The diameter of the 1st ring is 15 inches; area 225 circular inches.
" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36¾ "
} The area of each belt, between two rings, is the same as stated above.

In the above records, with 1oz. shot, the velocities come up almost exactly to our usual standard, and the patterns are generally regular, except that the fourth round with the choked barrel gave an abnormal pattern of only 99 pellets in the 30-inch circle. But this apparently irregular round, as a choke pattern, would have been almost ideal in its regularity as a cylinder pattern. Such regularity, however, could not have been demonstrated without the rings on the targets; but with them one may conclude that its "killing circle" would about double in area that of the ordinary 30-inch plate. And we can but suppose that this abnormal round was due to some peculiarity in the cap or wads of that especial cartridge.

With only ¾oz. shot, and 2½drs. of powder, it may naturally be expected that there would be some increase of velocity, and here we find the ten rounds average 1173 f.s.; while there is a decrease in pressure and recoil, as shown by the following tables:

2½ Drams of Powder with ¾oz. No. 6 Shot, in 16-Bore Gun.

(Barometer, 29·14in.; Thermometer—Wet bulb, 45°; Dry, 45°.)

16-Bore Gun; weight, 6lb. 8oz.; barrels, 30in. Powder, 2½drms.; shot, ¾oz. No. 6 (236 pellets). Wadding: "Field" wad, ⅜in. felt, and thick card, with thick card over shot. Gas pressure—average 2·66 tons per sq. inch; highest round, 3·12; lowest, 2·64 tons.

Right Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds). Ft.sec.	Recoil. Ft.lb.
1	25	32	16	21	15	16	94	142	1172	23·2
2	32	29	27	22	18	14	110	126	1186	24·0
3	29	25	24	16	12	16	94	142	1190	23·3
4	37	31	21	22	16	12	111	125	1190	24·0
5	28	21	13	23	12	21	85	151	1163	22·6
6	33	26	23	19	15	15	101	135	1158	22·9
7	39	29	20	16	18	17	104	132	1181	23·5
8	27	32	25	21	17	11	105	131	1167	23·1
9	35	18	14	20	19	8	87	149	1154	22·6
10	36	30	26	18	12	13	112	124	1167	23·0
Average	32	27	21	20	15	14	100	136	1173	23·2

Left Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	
1	32	35	30	28	13	10	125	111	
2	60	45	34	21	16	13	160	76	
3	52	43	31	25	19	16	151	85	Velocity and Recoil (as above).
4	47	34	25	33	11	13	139	97	
5	55	42	33	29	21	15	159	77	
6	63	45	29	23	17	11	160	76	
7	51	39	21	17	20	19	128	108	
8	37	33	19	19	15	21	107	129	
9	43	32	42	22	17	17	144	92	
10	62	41	35	20	15	16	158	78	
Average	51	39	30	23	16	16	143	93	

In the tables just given, as there was ¼oz. less shot in the cartridges, it might be anticipated that there would be somewhat smaller

patterns. And such was in fact the case. But while the number of pellets in the charge was reduced by 12½ per cent., the pattern in the 30in. circle was diminished about 9 per cent. with the cylinder barrel, and about 8 per cent. with the choked barrel.

Now we come to the 2-dram charges; and it is obvious that that quantity of powder is not sufficient for 1oz. of shot, as the velocities are low, averaging about 70 ft.sec. beneath the above-mentioned standard; and the cylinder patterns fall off numerically as well as in regularity, in comparison with those in the first of the tables that are given above.

2 Drams of Powder with 1oz. of No. 6 Shot, in 16-bore Gun.

(Barometer, 29·85in.; Thermometer—wet bulb, 45°; dry, 45°.)

16-Bore Gun; weight, 6lb. 8oz.; barrels, 30in. Powder, 2drms.; shot, 1oz. No. 6 (270 pellets). Wadding: "Field" wad, ⅜in. felt, and thick card, with thick card over shot. Gas pressure—average 2·52 tons per sq. inch; highest round, 2·64; lowest, 2·31 tons.

Right Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds). Ft.sec.	Recoil. Ft.lb.
1	30	20	21	22	17	20	93	177	1053	21·5
2	34	23	23	27	12	19	106	164	1103	21·2
3	26	17	16	15	23	15	74	196	1056	21·0
4	33	29	27	20	18	13	109	161	1099	21·6
5	30	33	24	18	11	11	105	165	1158	22·3
6	29	31	26	22	21	17	108	162	1071	21·7
7	37	22	21	19	20	16	99	171	1124	21·9
8	32	32	25	21	17	18	110	160	1064	22·0
9	26	27	24	20	14	12	97	173	1071	21·6
10	37	30	25	22	19	17	114	156	1136	22·1
Average	31	26	23	21	17	16	101	169	1094	21·7

Left Barrel.—Forty Yards Pattern.

Round.	1st. ring.	2nd ring	3rd ring.	4th ring.	5th ring.	6th ring	Inside 30 inch circle.	Outside 30 inches.	
1	66	42	29	22	20	12	159	111	
2	59	46	31	34	16	15	170	100	
3	63	43	28	30	22	15	164	106	
4	46	34	26	25	15	18	131	139	
5	55	50	33	26	18	16	164	106	
6	63	42	27	24	24	21	156	114	
7	58	49	32	27	21	11	166	104	
8	61	53	21	31	16	6	166	104	
9	41	41	28	28	20	14	138	132	
10	54	52	37	15	19	14	158	112	
Average	57	45	29	26	19	14	157	113	

Velocity and Recoil (as above).

With the ½drs. charge of shot also, 2drs. of powder is not to be recommended in the 16-bore, though it probably might suffice in the 20-bore, or guns of smaller gauge. In the following tables it will be seen that the velocities were about 50 f.s. below the standard; and the diminution of pressure and recoil would hardly compensate for loss of penetration.

2 Drams of Powder with ⅞oz. Shot, in 16-bore Gun.

(Barometer, 29·14in.; Thermometer—Wet bulb, 45°; Dry 45°.)

16-Bore Gun; weight, 6lb. 8oz.; barrels, 30in. Powder, 2drms.; shot, ⅞oz. No. 6 (236 pellets). Wadding: "Field" wad, ⅜in. felt, grey cloth, and thick card over shot. Gas pressure—average 2·34 tons per sq. inch; highest round, 2·49; lowest, 2·16 tons.

Right Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds). Ft.sec.	Recoil. Ft.lb.
1	38	30	23	21	15	11	111	125	1111	20·1
2	31	26	18	18	18	13	93	143	1103	20·0
3	33	33	21	21	15	18	108	128	1123	20·4
4	42	30	20	19	17	15	111	125	1128	20·4
5	36	15	32	13	16	14	96	140	1084	20·0
6	39	28	25	23	20	12	115	121	1119	20·2
7	28	21	20	26	18	17	95	141	1091	19·8
8	33	30	27	24	19	15	118	123	1124	20·7
9	45	28	13	25	10	10	111	125	1115	20·3
10	25	39	24	16	8	16	104	132	1067	20·0
Average	35	28	22	21	16	14	106	130	1107	21·2

Left Barrel.—Forty Yards Pattern.

Round	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	
1	49	27	21	24	20	15	121	115	
2	62	45	33	26	22	13	166	70	
3	66	52	31	17	16	8	166	70	
4	58	40	35	21	20	14	154	82	
5	65	39	26	18	16	11	148	88	
6	59	44	32	21	18	12	156	80	
7	68	46	34	23	14	9	171	65	
8	56	37	35	26	18	15	154	82	
9	66	48	32	27	20	12	173	63	
10	37	26	22	18	18	10	103	133	
Average	59	40	30	22	18	12	151	85	

Velocity and Recoil (as above).

The following short table gives a concise summary of the general results of the four varieties of loading in the same 16-bore gun:

Charges.	Patterns. Cylinder.	Choke.	Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
2¼drs. and 1oz.	110	156	1159	25·0	2·97
,, ,, ⅞oz.	100	143	1173	23·2	2·86
2drs. and 1oz.	101	157	1094	21·7	2·52
,, ,, ⅞oz.	106	151	1107	21·2	2·34

EXPERIMENTS WITH 2-INCH CARTRIDGES.

(*Field*, Jan. 23, 1897; Vol. 89, p. 106.)

With Ballistite.

Some time ago we made many trials with 2in. chamber guns, and in all of them we tried various powders, methods of wadding, &c., but failed to obtain satisfactory results. The principal cause of failure was that the concentrated powders did not ignite well in the flat-based cases, the result being low and irregular velocities. Lately, however, at the request of Messrs Nobel's Explosives Company, we again took the matter up, they supplying us with a quantity of cartridge cases manufactured by the Union Metallic Company, Bridgeport, Connecticut, U.S.A. These cases Messrs Nobel modified before sending them on to us.

The advantages accruing from the use of 2in. chamber guns are that, in consequence of the shortness of the chambers, the barrels may with safety be made somewhat lighter. But the saving of weight and bulk in the cartridges is of far greater importance, the loaded cartridge being only 1⅞in. in length. The reduction in weight and bulk of these short cartridges would doubtless be much appreciated by anyone who had to carry his own cartridges for a day's shooting. We here append the results of the trial in tabular form, and may remark that they are, in our opinion, exceedingly good.

Ballistite in 2in. Chamber Gun.

(Barometer, 29·50; Thermometer—Dry 39°, Wet 39°.)

12-bore gun; weight, 6lb. 10oz.; barrels, 30in. Charge of powder, 23grs.; shot, 1¼oz. (304 pellets), No. 6. Wadding: Thin card, ⅛in. felt, thick card, and thin card over shot. Gas pressure in barrel, average 2·69 tons per square inch (highest round 2·82 tons, lowest 2·61 tons). Cartridge cases made by the Union Metallic Co., U.S.A.

Right Barrel (slightly choked).—40 Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10yds.) Ft. sec.	Recoil. Ft. lb.
1	48	30	29	37	15	21	144	160	1176	27·5
2	52	40	33	28	23	17	153	151	1220	29·0
3	43	49	41	22	27	18	155	149	1158	27·3
4	46	38	30	34	23	22	148	156	1220	30·0
5	44	32	32	29	25	20	137	167	1205	28·0
6	50	36	35	30	19	17	151	153	1154	27·8
7	46	40	33	23	21	19	142	163	1181	27·9
8	48	35	34	31	23	18	148	156	1215	28·3
9	38	41	32	28	26	22	139	165	1172	27·2
10	49	37	31	26	24	23	143	161	1215	27·5
Aver...	46	38	33	29	23	20	146	158	1192	28·1

LEFT BARREL (modified choke).—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	76	48	34	32	23	13	190	114	
2	83	57	43	21	19	20	204	100	
3	53	54	38	32	27	18	177	127	
4	67	55	45	30	26	21	197	107	
5	84	61	32	28	18	19	205	99	
6	80	56	39	26	20	16	201	103	(As above.)
7	72	45	40	31	22	21	188	116	
8	86	52	37	29	19	16	204	100	
9	79	49	33	32	24	22	193	111	
10	81	64	38	27	20	14	210	94	
Aver.	76	54	38	29	22	18	197	107	

It will be noticed that high and regular velocities were obtained with only 23grs. of powder, whereas the usual charge is 26grs. In our opinion these results may be attributed to the strength and regularity of ignition; for, as a matter of course, with so short a cartridge, a coned base could not be used.

In order to ascertain how these little cartridges would behave in a gun bored for cartridges of the usual length we fired a number of them from a 12-bore, having the right barrel cylinder and the left choke. This gun usually gives a pattern of 130 with right barrel and 180 with the left, and a mean velocity in 10 yards of about 1160 ft.sec.

We subjoin the records taken in this trial and it will be noticed that in consequence of the cartridge being so much shorter than the chamber the difference in velocity was a negligeable quantity. The average patterns are—with the right barrel, fifteen pellets less, and with the left twenty-one pellets less in the 30in. circle.

2IN. BALLISTITE CARTRIDGES IN 12-BORE GUN WITH FULL LENGTH CHAMBERS

(Barometer, 29·72; Thermometer—Dry 44°, Wet 44°.)

12-bore gun; weight, 7lb.; barrels, 30in.; charge of powder, 23grs.; shot, 1¼oz. (304 pellets) No. 6; gas pressure as in previous experiments; cartridge cases made by the Union Metallic Co., U.S.A.

CYLINDER BARREL.—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10yds.) Ft. sec.	Recoil Ft. lb.
1	30	28	27	27	16	21	112	192	1154	25·9
2	36	27	37	20	25	18	120	184	1149	25·3
3	35	25	26	25	18	23	111	193	1145	25·7
4	30	33	21	19	14	17	103	201	1141	25·1
5	33	30	30	27	24	21	120	184	1176	26·0
6	35	27	31	24	22	23	117	187	1154	26·0
7	28	34	24	21	26	20	107	197	1163	25·6
8	40	33	28	26	22	20	127	177	1149	25·2
9	34	33	27	24	23	14	118	186	1158	25·0
10	36	29	25	23	19	17	113	191	1172	25·8
Aver.	34	30	28	24	21	19	115	189	1156	25·6

CHOKE BARREL—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	63	34	39	36	17	15	172	132	
2	54	38	24	29	23	18	145	149	
3	60	40	36	30	25	19	166	138	
4	52	37	32	27	20	22	148	156	
5	64	32	40	35	16	19	171	133	
6	56	44	38	26	18	16	166	138	(As above.)
7	49	39	37	33	25	20	157	147	
8	53	33	24	21	19	18	130	174	
9	63	47	35	19	24	17	164	140	
10	61	43	38	27	22	19	168	136	
Aver.	58	39	34	28	21	18	159	145	

The 2in. chamber gun used in these trials was specially made by Messrs Joseph Lang and Son, of 10, Pall Mall, S.W.

TRIAL OF 12-BORE GUN WITH 2-INCH CHAMBERS.

(*Field*, Feb. 27, 1897; Vol. 89, p. 281.)

WITH SCHULTZE AND BLACK POWDERS.

SIR,—Since your trials with the 2in. chamber gun for condensed powders, we have had numerous inquiries respecting this weapon, but find that several of our customers raise the question as to what happens in the event of their running short of 2in. cartridges, and can they use the ordinary full-length cartridge? To this query we reply in the affirmative, as we have carried out lengthy experiments, and have succeeded in designing a gun to take the 2in. case, and in which can also be used the full length case with equally good results, and with any powder (Black or Smokeless), without extra pressure or any other disadvantages.

If you will allow us to send one of these guns on to you for trial, we shall be most pleased to do so. JOSEPH LANG AND SON.

10, Pall Mall, London, S.W., Feb. 11, 1897.

[We have made a trial of the gun above alluded to, both with Schultze and No. 4 Black powder, and give the results in tabular form below. The trial alluded to was carried out with Ballistite, and appears in the preceding column.—ED.]

The gun is chambered for the 2in. cartridge, but between the chamber and the bore of the barrel there is an exceedingly long and gradual cone; this enables cartridges of the full length (viz., 2½in.) to be fired without any extra pressure upon the breech. To ascertain this we made the following trials:

2½in. cartridges in ordinary 2½in. chamber, 42grs. Schultze, 1⅛oz. No. 6 shot, wadding as usual.

Tons per square inch.						Average.
1·88	1·83	2·04	1·41	1·41	1·78	1·72

Cartridges loaded exactly the same as above, and fired in 2in. chamber with long cone.

Tons per square inch.						Average.
1·41	1·47	2·20	1·96	1·63	1·88	1·76

2½in. cartridges in ordinary 2½in. chamber, 82grs. No. 4 Black powder, 1⅛oz. No. 6 shot, wadding as usual.

Tons per square inch.						Average.
2·31	2·24	2·28	2·37	2·20	2·31	2·28

Cartridges loaded same as above, in 2in. chamber, with long cone.

Tons per square inch.						Average.
2·28	2·40	2·34	2·24	2·31	2·34	2·30

It will be seen that these results fully bear out the statements made in Messrs Lang's letter, and remove the only objection that could be urged against the expediency of adopting the 2in. chamber gun. The following are the results of experiments at the target—the surface of which is divided into six rings of equal area, as in former trials.

SCHULTZE and BLACK POWDERS, in ordinary 2½in. cases.

(Barometer, 30·18in.; Thermometer—Dry 55°, Wet 55°.)

12-bore gun; weight, 6lb. 10oz.; barrels, 30in. Charge of powder, 42grs. Schultze; 1⅛oz. (304 pellets) No. 6 shot. Wadding: thin card, ⅜in. felt, grey cloth, and thin card over shot.

RIGHT BARREL (slightly choked).—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10yds.) Ft. sec.	Recoil. Ft. lb.
1	55	41	34	28	21	15	158	146	1167	28·0
2	49	43	30	32	23	20	154	150	1154	27·0
3	47	39	36	30	20	16	152	152	1151	28·2
4	50	41	31	26	18	23	148	156	1172	27·6
5	44	38	42	32	26	21	156	148	1158	27·3
6	51	42	33	25	20	18	151	153	1168	27·1
7	41	37	40	29	22	21	147	157	1149	26·3
8	49	42	31	30	17	16	152	152	1167	26·8
9	50	40	35	25	19	23	150	154	1176	27·5
10	46	48	33	30	25	19	156	148	1158	26·4
Aver.	48	41	34	29	21	20	152	152	1165	27·2

LEFT BARREL (modified choke).—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity & Recoil.
1	80	55	40	28	20	15	203	101	
2	73	52	44	31	24	19	200	104	
3	86	60	42	24	18	16	212	92	
4	81	56	35	29	21	14	201	103	
5	75	52	38	26	17	18	191	113	
6	80	57	40	31	26	23	208	96	(As above.)
7	76	62	43	24	17	15	205	99	
8	78	49	45	33	23	21	204	100	
9	84	61	36	28	19	17	209	95	
10	61	58	47	30	22	20	196	108	
Aver.	77	56	41	28	21	18	202	102	

(Barometer, 30·10in.; Thermometer—Dry 53°, Wet 53°.)

12-bore gun; weight, 6lb. 10oz.; barrels, 30in. Charge of powder, 32grs. No. 4 Black; 1⅛oz. (304 pellets) No. 6 shot. Wadding: thin card, ¼in. felt, grey cloth, and thin card over shot.

RIGHT BARREL (slightly choked).—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. (10yds.) Ft. sec.	Recoil. Ft. lb.
1	42	37	32	26	21	19	137	167	1158	34·1
2	39	39	36	30	25	22	144	160	1167	34·2
3	46	45	33	27	20	16	151	153	1186	35·0
4	50	43	29	24	17	12	146	158	1141	33·8
5	37	40	35	29	23	18	141	163	1158	34·0
6	45	36	30	32	21	20	143	161	1167	34·4
7	43	38	28	26	18	18	135	169	1163	34·3
8	50	41	32	23	17	15	146	158	1154	34·0
9	40	39	35	31	26	21	145	159	1172	34·8
10	41	42	38	27	19	22	148	156	1176	34·6
Aver...	43	40	33	27	21	18	144	160	1164	34·3

LEFT BARREL (modified choke).—40 YARDS PATTERN.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Total in 30in. circle.	Outside 30in.	Velocity. Ft. sec.	Recoil. Ft. lb.
1	72	51	33	28	22	16	184	120		
2	78	44	35	24	19	18	181	123		
3	81	45	31	22	16	13	179	125		
4	75	50	40	26	23	21	191	113		
5	68	47	34	30	22	18	179	125		
6	79	46	32	25	20	16	182	122	(As above.)	
7	83	50	42	27	18	20	202	102		
8	64	44	38	30	23	15	176	128		
9	78	52	33	29	24	20	192	112		
10	70	46	41	31	20	17	188	116		
Aver...	75	47	36	27	21	17	185	119		

NOMENCLATURE OF BORES OF GUNS.

(*Field*, Jan. 27, 1894; Vol. 83, p. 126.)

SIR,—Would you kindly tell me the origin of the word "bore" in ylindrical guns, taking the more common 12-bore gun and comparing it with the 8-bore or any larger or smaller bores? H. F.

[The bores of guns received their designations from the size (or rather the weight) of the largest spherical projectiles which could be used therein. In like manner as artillery were called 7-pounders, 32-pounders, &c., according to the weight of the iron round shot with which they were ordinarily used, so were small arms designated in accordance with the weight of the spherical lead bullets which they would admit into the bore. Hence, a barrel made with such a size of bore as would take lead balls of twelve to the pound was called a 12-bore; one which would take balls of four to the pound was called a 4-bore; and so on. In comparatively recent times the diameters of the respective bores for small arms have been laid down in the Acts of Parliament and schedules regulating the proof of guns. We give a few of them:

Number of Gauge.	Diameter of Bore.	Number of Gauge.	Diameter of Bore.	Number of Gauge.	Diameter of Bore.
1	1·669 inch.	12	·729 inch.	28	·550 inch.
2	1·325 ,,	14	·693 ,,	32	·526 ,,
4	1·052 ,,	16	·662 ,,	36	·506 ,,
8	·835 ,,	20	·615 ,,	40	·488 ,,
10	·775 ,,	24	·579 ,,	48	·459 ,,

These measurements represent the diameter when the bullets are of ordinary soft lead (specific gravity 11·352). Hardened bullets of the same size are less in weight, owing to the alloy being of lower specific gravity than pure lead. It will be observed, on comparing some of the figures in the above table, that the weight of the bullets vary in proportion to the "cube" of their diameter. Thus, a 32-bore spherical lead bullet is 526 thousandths of an inch in diameter; and, as thirty-two such bullets weigh a pound, each one consequently weighs half an ounce. If that diameter be doubled, the measurement will be 1·952 inches; and a bullet of that size weighs 4oz., or eight times as much as one of 32-bore. By using or reversing this process, it will be found that a 16-bore is half the diameter of a 2-bore; a 3-bore is double the diameter of a 24-bore; and so on. There are minute differences apparent, but these merely arise from the decimal fractions being limited to thousandths of an inch.—ED.]

SMALL-BORE GUNS.

(*Field*, Dec. 25, 1897; Vol. 90, p. 1012.)

SIR,—Just a word about small-bores. So many of your correspondents seem to think that a small-bore is necessary if a man require a light gun. The gun I now use most is a choked 12 by Turner, 28in. barrels (numbered 4137), balance 1½in., weight 5lb. 9½oz.; best charge, 38½grs. Schultze and 1oz. shot; *Field* loading. This gives a good pattern and penetration. Another gun, which I have shot with for more years than one cares to talk about, is also a Turner and a 12. It has 27½in. barrels, and weighs 6lb. 2oz., but is cylinder bored, and the load is 42grs. and 1⅛oz. The lighter gun will kill ten yards further.

Many years ago I pointed out in the *Field*, over the signature J. T. B., that small-bores possessed the disadvantage of a badly-shaped powder chamber, the length being too great in proportion to the diameter, thereby producing abnormal pressures. The theory was disputed, and my friend the late Mr Walsh (then editor of the *Field*) had the idea tested practically, and published the results, which entirely agreed with my proposition.

It is important, however, to note that the recent introduction of stronger powders, per unit of space occupied, is in favour of small-bores, because, in the event of experience proving that such powders are reliable in the field, it is evident that the best-shaped chamber for these powders will be found in some bore smaller than a 12; perhaps 16, perhaps 20.

I have very little doubt that the best shaped powder chamber is one where the diameter does not differ greatly from the length, and if a sportsman will settle the charge of shot he wishes to employ, the powder charge of new explosive is also fixed, as also the space it occupies; and the best bore at once follows from the above consideration of equal length and diameter for the powder chamber. The total weight of gun also follows, unless a man wants to be kicked to pieces, and get gun headache. Hence, metal in barrels of a desired length and amount of wood in stock are fixed.

It all comes logically from the charge of shot and the quality or description of powder employed to propel it. With the usual shot charge of 1 or 1⅛oz., I think it will be found that Schultze, E.C., and kindred powders will logically produce the best possible guns at 12-bore, whereas with powders of a more concentrated nature guns of smaller bore will be the best possible bothas regards small weight and performance.

For my own part I am perfectly satisfied with a 5½lb. 12 choke and Schultze powder. FOREST GUN.

[We quite agree with "Forest Gun" that light 12-bores may be used effectively with 1oz. charges of shot. Some correspondents apparently have come to a different conclusion, after reading the results of experiments which we carried out last year, and seem to think that light 12-bores give an excessive amount of recoil. Such is not necessarily the case, however; but one fact was conclusively proved by those experiments, viz., that lightness may be carried to excess, and that a 12-bore of 5lb. weight gives much more recoil than a 16 or 20-bore that is a pound heavier. In short, the 12-bore class of last year was as a whole somewhat unduly handicapped by the inclusion of two very light guns with 24in. barrels, the lightest of which weighed only 4lb. 14oz.; and the shorter the barrels are, the greater is the amount of powder requisite to impart a given velocity to the shot. For the purpose of demonstrating this more effectively, we will summarise the results of last year's trial of 12, 16, and 20 bores, and will subdivide the 12-bore class, so as to show the difference of results between the three heaviest, which averaged 5lb. 13oz., and the three lightest guns of the same bore, which averaged only 5lb. 2oz. The charge of shot was 1oz. throughout, and the explosive used was Schultze powder.

Bore.	Weight. lb.	oz.	Barrels. Inches.	Powder. Grains.	Patterns. Cylinder.	Choke.	Velocity. Ft.sec.
12	5	13	27	37	109	131	1164
	5	2	24½	39	108	152	1161
16...	5	12	28	36	107	145	1165
20...	5	9½	28	33	100	134	1168

It will here be seen that the differences in pattern and velocity were small; but the shorter barrels necessitated the use of more powder. One consequence of this was that the recoil was increased. With the three heaviest 12-bore guns it averaged 27·8 ft.lb.; whereas with the three lightest it averaged 30·7 ft.lb.; with the 16-bores it averaged 26·9 ft.lb., and with the 20-bores 27·2 ft.lb. Another difference was the amount of pressure in the barrel, the narrower the gauge the higher being the stress. With the 12-bores it averaged 1·79 tons per square inch; with the 16-bores, 2·60 tons; and with the 20-bores, 3·14 tons.—ED.]

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"ON BLACK AND NITRO POWDERS FOR SPORTING GUNS."*

(*Field*, Feb. 5, 1898; Vol. 91, p. 177.)

SUCH is the title of a *brochure* of some seventy-seven pages containing the subject of a paper read before the Gunmakers' Union of Belgium, at Liége, in January, 1897, by Mons. Jules Polain, the director of the Government Proof House in that city. The official position held by the author has, no doubt, drawn greater attention to this publication than would have been the case had the writer been more or less unknown. He commences by laying stress on the great importance of a close experimental study of both the black and the nitro powders used in sporting guns, not only because the subject is of interest to gunmakers, but also because it is closely connected with the question of the safety of the public.

M. Polain's views may be summarised as follows: In order to make good weapons, gunmakers should understand the action of explosives. But few of them trouble themselves about such matters; and many do not even now make their weapons with any definite knowledge either of the stresses the gunbarrels will be subjected to, or of the strengths that they possess. Would anyone, he asks, start to make the boiler of a steam-engine without first ascertaining what pressure it was to be worked at? In comparing the boiler and the firearm (both of which are tested by the State) he points out that whilst the former may not be worked at a higher pressure than that authorised by the State, there is no such limitation in the case of the gun—the user of which determines the pressure by the charges that he employs. Nor does the gunmaker, of the present day even and in any country, make any calculations or experiments to ascertain whether in fulfilling the requirements of the sportsman he is not exceeding the limit of safety. For example, a feather-weight gun is asked for, and the gunmaker removes the metal until the weight is attained; he does not know or care what powder or charge is going to be used in it—the only point that he considers is that he must not lose a customer.

This system is wrong in principle. The gunmaker is the person who ought to know what his gun can and with safety withstand; he should prescribe the maximum charges and description of powder to be used. The prevalent idea amongst sportsmen is that their weapons have been tested by the State, and are therefore safe for any sort of powder or charge that they can get into them. When a gun bursts it is difficult to apportion the blame.

M. Polain then touches upon the elements of a cartridge, and the importance of each part of it—the cap, powder charge, wads and shot—as affecting the ballistics obtained.

To show the danger that exists—more especially with the nitro powders—a large number of diagrams are given, showing the pressures obtained along the bore, with normal and proof charges, of various well-known Belgian, English, and French sporting powders. The pressures were taken at the Proof House at Liége, in multiple-crusher guns of 12, 16, and 20-bore respectively, designed by the author of the pamphlet. The Polain crusher-gun, in its main features, is very similar to the one with which the *Field* experiments have been carried out for years past, except that our apparatus has six crushers, while M. Polain's has ten. Our records, with the moderate pressures that occur in shot guns, are taken with lead cylinders; whereas those of M. Polain are taken with copper cylinders of much smaller dimensions. And we fire separate rounds when testing the pressures at each plug, because we believe that, under such conditions, the individual records are more reliable; while M. Polain takes multiple pressures at the whole ten plugs, from the firing of a single cartridge.

Every precaution is said to have been taken in the loading and general treatment of the cartridges used in M. Polain's experiments. These diagrams for the most part show extraordinarily high pressures towards the muzzle—in many cases the pressure recorded being higher there than at the breech. On these results M. Polain bases the whole of his arguments and most of his advice, not only to the gunmakers themselves but to the users of their guns; and he formulates a number of rules on the choice of a gun, the selection of a suitable powder and weight of charge, and on the actual loading of the cartridge. Furthermore, he states that the normal service charges of all the nitro powders and some of the extra fine black develop more or less dangerous pressures in some parts of the gun.

If nitro powders must be used (and he allows they have much to recommend them), then only low charges should be employed, of which he gives a table; and light guns must not be thought of. In fine, he considers—though it is difficult to take this statement seriously—that a French gunmaker is correct in his view of the situation, who puts in his catalogue the following announcement: "This high-quality gun which we manufacture for black powder is sure to burst sooner or later if anyone is rash enough to fire it with nitro powder."

M. POLAIN'S SECOND PAMPHLET.

In a second pamphlet published during the same year* "On the responsibilities in case of accidents through bursting of guns," he deals very briefly with the subject of the title, only two pages out of the thirty-four being devoted to this matter. The relative responsibility of the powder-maker, gunmaker, and user is considered to be gradually becoming more justly apportioned; for whereas formerly, when a gun burst, the blame fell on the gunmaker alone, while the powder-maker always got off scot free—and the former, to save his reputation and to avoid an action at law hushed the matter up and paid the damages claimed—more recently it is only after the cartridges have been, so to speak, tried and proved innocent that the gun is found guilty.

The rest of the pamphlet is devoted to some correspondence and letters in the *Chasse Illustrée* on the subject of high pressures with nitro powders, and to some further experiments made with M. Polain's gauge, and in his presence, at Engis, at the factory of Messrs Muller and Co., with the latest issues of the powders previously experimented with. In the records given in this pamphlet the excessive forward pressures have disappeared, and more moderate ones have taken their place. This, however, is attributed solely and entirely to the manufacturers having modified their powders in consequence of the published results of the previous experiments. No evidence to support this assertion is given; but the statement is reiterated that the experiments of 1896 showed high pressures at the muzzle, sometimes even exceeding those recorded at the breech, the cause of which pressures has not been explained by anyone, including M. Polain himself, the pressures themselves being assumed by him to be indisputable, and above suspicion of error.

M. QUERSIN'S PAMPHLET.

It is not surprising that the remarkable results obtained and published by M. Polain in his first pamphlet attracted the attention of his fellow countrymen; and a short *brochure*† from the pen of Mons. H. Quersin (an advocate at the Brussels Court of Appeal) appeared towards the end of the year. This work contains a severe criticism of M. Polain's theories and his results.

M. Quersin has divided his pamphlet into six chapters: (1) dealing with M. Polain's theories; (2) enunciating the elementary principles which govern the combustion of a charge; (3) a general view of the various methods of ascertaining pressures in a gun; (4) shows that theoretical pressures should and do agree with observed ones; (5) a criticism of M. Polain's actual experiments; (6) conclusion.

Whether an amateur or not, M. Quersin has evidently studied his subject, and expresses his conclusions tersely and pointedly. Dealing with M. Polain's theories, he says they are all based upon his multiple-gauge records, and that they are as follows: (1) the pressure does not necessarily decrease as the shot travels down the bore; (2) the pressure at the muzzle is not infrequently higher than that at the breech. Furthermore, the dangerous points in the barrel have been fixed by his diagrams.

These new theories, says M. Quersin, are so revolutionary that they should be sifted to the utmost before accepting them as correct. The idea of measuring pressures in a gun is no novelty; it is a very old problem, that of ascertaining the charge of explosive which will give the highest velocity to the shot without subjecting the barrel to undue stresses. The most eminent authorities have formulated in the clearest terms the manner of burning of an explosive in a gun—how that, after a maximum pressure is obtained, there is a fall of pressure more or less rapid, due to the expansion of the gases and the loss of heat by conduction through the metal of the barrel. The principal elements affecting the maximum pressure are the physical and chemical conditions of the explosive used.

As regards the pressures themselves there are two general methods

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Des Poudres Noires et des Poudres Pyroxylées pour Fusils de Chasse; Résumé de la Conférence donnée le 18 Janvier, 1897, à l'Union des Fabricants d'Armes, sous les auspices de la Commission Administrative du Banc d'Epreuves des armes à feu, de l'Union des Fabricants d'Armes, et du Musée d'Armes de Liége. Par Jules Polain, directeur du Banc d'Epreuves, Commissaire du Gouvernement chargé de la haute surveillance des Armes à feu dans le Royaume. Liége: Imprimerie Charles Gothier. 1897.

* Des Responsabilités en cas d'accidents par Rupture d'Armes de Chasse. Par Jules Polain, Ingénieur et Docteur en droit. Directeur du Banc d'Epreuves des Armes à feu, Liége. Imprimerie H. Vaillant Carmanne, Liége. 1897.

† Des Poudres Pyroxylées pour Fusils de Chasse. Quelques Mots en Réponse, &c. Par Henri Quersin, Avocat près la Cour d'Appel de Bruxelles. Paul Lacomblez, publisher, Brussels. 1897.

of obtaining them: (1) by instruments measuring the velocity of recoil or the velocity of the shot in the bore, from which the pressures can be calculated; (2) by instruments for measuring the pressure direct. The crusher-gauge is an instrument of the second class, wherein a copper cylinder is compressed by the action of the gases on a piston of known area, and M. Polain's gauge is of this nature. The most eminent authorities, however, agree that, to ensure accuracy, the crusher-gauge should be placed near the breech, and that even then the results are not to be trusted unless verified, presumably by some other method.

A number of English experiments are quoted by M. Quersin to prove from the absence of high forward pressures that M. Polain's results are, from some cause or other, incorrect. In the fifth chapter M. Quersin's criticism almost amounts to a denunciation of M. Polain, whom he accuses of posing as an authority on a subject of which he knows little or nothing; of having used the wrong weights of powder and shot for service charges in his experiments; and of having not only ignored the instructions for loading issued by the manufacturers, but of having fired heavier charges than those recommended by them for the maximum service charge, as well as heavier loads of shot.

In conclusion and reviewing the question M. Quersin is of opinion that some mistake has been made, and considers it M. Polain's duty to repeat his experiments, taking every advantage of the experience in apparatus and results of experiments made in England. If the same results are again obtained he (M. Quersin) will be the first to apologise; if not, then he hopes that M. Polain will frankly admit his mistake.

Whilst the above-mentioned pamphlet was in the press M. Polain's second pamphlet appeared; and M. Quersin therefore added some remarks on this also. He considers it to be merely a cover to hide a skilful retreat from the former position found to be untenable, as though published under the title "On responsibility in case of accident due to guns bursting," scarcely any space is devoted to that subject, by far the greater portion being taken up with further experiments with the multiple crusher-gauge and explanations thereon. The further experiments did not show the extraordinarily high pressures towards the muzzle that were previously obtained, and M. Polain explains that this is due to the manufacturers having altered their powders—all samples used being of 1897 issues. M. Quersin, however, on the written evidence of the manufacturers of the powders, denies that any alteration has been made in their manufacture; and he infers that it is the multiple crusher-gauge that has been altered—adding, that it is a most remarkable coincidence that all the powders should have altered in the same favourable manner.

Some English Experiments with M. Polain's Multiple Crusher-Gauge.

Having, in the foregoing paragraphs, summarised the main features of three *brochures* which we have received from Belgium, we now proceed to lay before our readers some results which have come within our personal experience in connection with the subject at issue.

When M. Polain's first pamphlet reached us, in the early part of last year, we could not but be struck by the very extraordinary results which were there set forth. We say "extraordinary," advisedly, because they were utterly at variance with our own experience in the numberless trials of guns and explosives which we have carried out ourselves during many years past, or that have been carried out in our presence by others.

We did not, however, at the time comment on the pamphlet we received, as we were not acquainted with the nature of the apparatus that was said to have given such results. But we have recently had an opportunity of trying experiments with "l'appareil à multiples crushers, système Jules Polain," and now proceed to state the outcome of our investigations.

The barrel of M. Polain's crusher-gauge is 29½in. in length, and it is fitted with ten plugs—their respective distances from the breech being approximately as follows (in inches): first plug, 0·7; second, 2·5; third, 4·4; fourth, 6·4; fifth, 8·3; sixth, 10·3; seventh, 12·2; eighth, 14·2; ninth, 21·4; and tenth, 28·5in. So it will be seen that in the first half of the barrel there are eight plugs, separated by intervals of nearly two inches; and in the second half of the barrel there are but two plugs, which are about seven inches apart.

The whole of the ten plugs are operated upon by the firing of one charge of powder and shot, after which the small copper cylinders, used as crushers, are taken out and measured, and the pressure on each is estimated in accordance with a scale prepared by M. Polain for that purpose.

The ten plugs are fitted into a corresponding number of screwed sockets—these, again, being provided with set screws. The result of this complication is that the copper crusher is hidden from sight, in the interior of the screwed socket; so that it is impossible to ascertain, before firing the gun, whether each of the ten little copper cylinders is in its correct position. Moreover, these screwed sockets are not interchangeable, neither are they marked; consequently, in the event of the sockets getting intermingled, there is a risk of some of the plugs becoming jammed, and therefore not acting properly. Hence the liability to error is by no means remote. But, providing that everything is nicely adjusted, the gauge carefully used, and the copper cylinders remain in their proper central positions, the instrument would be likely to act as well as other gauges that are in use in England, and to give similar results.

We have lately carried out extensive trials with one of M. Polain's gauges, but the results that we have obtained are widely different from those stated in M. Polain's first publication, although we have used nearly all the nitro powders known in England, and have tried our utmost to obtain high pressures at the muzzle. We give below the results of some of our trials in tabular form. The powder used in this instance was Schultze of 1896 issue—that being one which, according to M. Polain, gave some of the very extraordinary results stated in his first pamphlet. We have likewise tested the 1897 sample of Schultze powder, and find no practical difference in the results exhibited by the two issues.

Before entering into any of the details, however, we will briefly summarise some particulars given by M. Polain relative to three kinds of powder—two being English and one French, that has been much used by foreign competitors at the international pigeon-shooting competitions at Hurlingham and the Gun Club. The pressures are stated in atmospheres, of which, at 14·78lb. per atmosphere, about 152 would be equivalent to a ton per square inch.

	1st plug.	2nd plug.	3rd plug.	4th plug.	5th plug.	6th plug.	7th plug.	8th plug.	9th plug.	10th plug.
Schultze	426	408	458	450	444	438	378	450	504	516
E.C.	408	360	390	474	294	360	396	378	582	588
S. No. 2.	468	408	408	402	438	438	522	624	630	582

It will be observed that, with all three powders, the pressures are represented to be higher at the muzzle than at the breech, while the French powder has its two highest pressures at the eighth and ninth plugs. And the most marvellous part of the business is that, although the barrels are usually thinnest at the parts where these very high pressures are alleged to occur, people go on using their guns with impunity; whereas, if the facts were as set forth in this pamphlet, the barrel ought to be thicker near the muzzle than it is at the breech. The only conclusion we can come to is that there was something wrong in the working of the apparatus when the records alluded to were taken; for no such results were indicated in the course of our experiments, the records of which are here given:

Trials with M. Polain's Pressure-Gauge.

45 grains of Schultze (1896 manufacture), with 1⅛oz. of No. 6 shot. Wads: thin card, ⅝ inch felt, grey cloth, and thin card over shot. Eley's best nitro cases.

Round.	1st plug.	2nd plug.	3rd plug.	4th plug.	5th plug.	6th plug.	7th plug.	8th plug.	9th plug.	10th plug.
1	294	300	360	300	264	216	210	—	—	—
2	452	414	462	336	276	222	210	—	—	—
3	420	498	456	318	258	210	—	—	—	—
4	300	318	378	300	264	222	210	—	—	—
5	324	336	372	282	246	—	—	—	—	—
6	420	432	462	270	258	240	210	—	—	—
7	318	360	426	282	210	210	—	—	—	—
8	408	438	456	312	240	234	216	—	—	—
9	294	312	366	282	258	228	210	—	—	—
10	384	420	468	294	270	240	—	—	—	—
11	414	432	468	312	288	228	—	—	—	—
12	402	420	444	306	264	234	216	—	—	—
13	336	408	450	330	270	228	210	—	—	—
14	288	300	348	258	222	216	210	—	—	—
15	408	426	468	318	252	246	—	—	—	—
16	324	342	384	276	240	—	—	—	—	—
17	426	438	456	306	264	234	210	—	—	—
18	354	402	462	294	234	216	—	—	—	—
19	300	324	360	276	234	222	210	—	—	—
20	402	432	456	324	270	228	210	—	—	—
Averages	348	388	425	299	254	226	211	—	—	—

It will be observed that beyond the 7th plug (at 12·2 inches from the breech) there is a succession of blanks with every round. The reason of this is that at the 8th, 9th, and 10th plugs (and occasionally at the 6th and 7th) pressures were so low that they did not come

within the scope of M. Polain's table; and hence, as the actual pressures are not ascertainable from the table of reference, these spaces are necessarily left blank. In order to obtain reliable results it is absolutely necessary to employ more sensitive crushers near the muzzle than near the breech, whereas M. Polain's crushers are the same for all positions.

As pressures in atmospheres are not familiar to readers of the *Field*, we convert them into tons per square inch; and the averages shown in the last line of the above table will correspond with the first line of the following short summary; while the second line of this next table corresponds with M. Polain's first record given above (with two English powders and one French), where the pressure set forth with Schultze was 426 atmospheres at the first plug, and 516 atmospheres at the last. We first state the ton equivalents derived from the amospheric averages obtained in our own trials with M. Polain's apparatus (as printed above), and then add the corresponding ton equivalents of records published in M. Polain's first pamphlet, as having occurred with the same powder (viz., Schultze of 1896 issue).

Schultze Pressures in Tons per sq. inch at the respective plugs.

	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.
Our trials..	2·26	2·55	2·79	1·97	1·67	1·49	1·39	rest under 1·38 tons		
M. Polain's	2·80	2·68	3·08	2·96	2·92	2·88	2·48	2·96	3·31	3·40

The charge used by M. Polain was slightly heavier than ours, viz., 2·98 grammes (or 46 grains) of Schultze, with 36 grammes (or rather over 1¼oz.) of No. 6 shot; and, taking this into consideration, there appears but little difference at the early plugs between M. Polain's records and our own. At greater distances from the breech, however, where M. Polain's figures indicate a considerable increase of pressure, we found a considerable decrease, not only when using our own apparatus, but also when using M. Polain's apparatus; as the results thereby given did not confirm his conclusions, for the pressures from the seventh to the tenth plug were all so low as not to make any definite record.

The next table shows the pressures we have obtained with M. Polain's gauge when using the ordinary game charge of 42grs. of Schultze with 1⅛oz. of shot.

42 grains of Schultze (1896 manufacture), with 1⅛oz. of No. 6 shot. Wads: thin card, ⅜ inch felt, grey cloth, and thin card over shot.

Round.	1st plug.	2nd plug.	3rd plug.	4th plug.	5th plug.	6th plug.	7th plug.	8th plug.	9th plug.	10th plug.
1	264	270	360	288	246	216	—	—	—	—
2	228	228	276	252	—	—	—	—	—	—
3	288	294	366	282	252	—	—	—	—	—
4	264	270	330	270	234	—	—	—	—	—
5	276	294	336	264	228	—	—	—	—	—
6	306	336	360	264	234	—	—	—	—	—
7	306	342	348	264	216	—	—	—	—	—
8	252	252	318	258	234	—	—	—	—	—
9	312	342	390	276	240	—	—	—	—	—
10	318	360	366	264	240	—	—	—	—	—
11	258	258	318	258	228	—	—	—	—	—
12	282	300	372	276	246	—	—	—	—	—
13	270	288	348	264	234	—	—	—	—	—
14	240	246	294	258	—	—	—	—	—	—
15	300	312	378	264	228	—	—	—	—	—
16	288	294	318	282	254	218	—	—	—	—
17	306	342	366	276	246	—	—	—	—	—
18	234	234	312	240	228	—	—	—	—	—
19	282	312	372	294	252	—	—	—	—	—
20	264	276	318	272	234	222	—	—	—	—
Averages	277	292	324	268	239	219	—	—	—	—

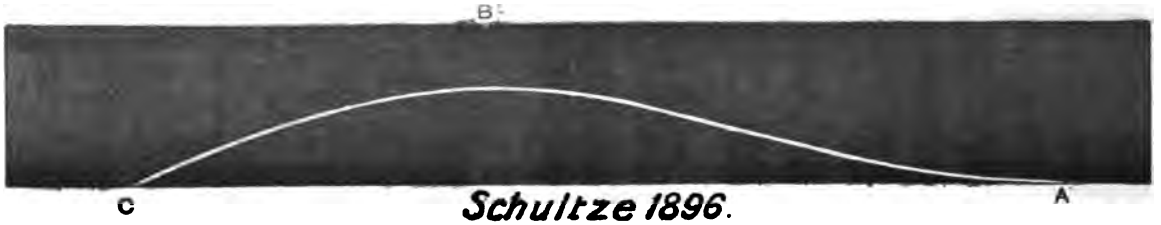
Here it will be observed that there are more blanks than appear in the previous table. But this is not surprising, seeing that the pressures would be lower with the smaller charge. In order to show what have been the pressures indicated towards the muzzle in our own apparatus, we reprint from an article which appeared in the *Field* of Nov. 21, 1896, giving "Curves of Pressure in the Barrel with Proof and Nitro Powders," the records taken by our own crusher-gauge with 42grs. of Schultze and 1⅛oz. of shot. Our apparatus has but six plugs; and we therefore state what were the pressures per square inch at those points, and place underneath, for facility of comparison, the corresponding pressures at the six nearest plugs in M. Polain's apparatus, as deduced from the number of atmospheres stated in the line of averages given at the foot of the last table given above.

42grs. Schultze, with 1⅛oz. shot.

	1st plug, breech.	2nd plug, 2½in.	3rd plug, 6in.	4th plug, 12in.	5th plug, 18in.	6th plug, 24in.
Field gauge	1·69 tons	1·49 tons	1·36 tons	0·92 ton	0·55 ton	0·32 ton
	1st plug, 0·7in.	2nd plug, 2½in.	3rd plug, 6in.	7th plug, 12in.	9th plug, 21½in.	10th plug, 28½in.
M. Polain's gauge.	1·82 tons	1·92 tons	1·76 tons	The rest under 1·38 tons.		

It will be seen that the last three plugs in the *Field* crusher-gauge recorded pressures down to one-third of a ton; while there was no record with M. Polain's gauge, as it did not supply particulars of any pressures that were below 1·38 tons.

Bearing in mind the high position held by M. Polain, we have spent much time and care in order to thoroughly test his theory; and with that object in view we made a new form of pressure-gauge,



which gives a continuous record of the pressure from the ignition of the cap to the clearing out of the powder-gases down to atmospheric pressure. This gauge is fitted with a plunger, having an area of $\frac{1}{100}$ of a square inch, and is provided with a marking point. The plunger is backed up by an exceedingly strong volute spring. The weight of the moving parts is very small, and therefore the marker is free to record any variation of pressure that may occur in the interior of the barrel. When the explosion takes place, the marking point describes a curve on the smoked periphery of a metal drum, revolving at forty revolutions per second. The accompanying diagram is a photographic enlargement of such a curve, (A) being the point where the ignition of the cap takes place. It will be noticed that the pressure rises very gradually at first to its maximum point (B), and then gradually declines to (C); and we may remark that this curve is a typical one, selected from many hundreds of trials, in none of which were there any irregularities or zigzags of pressure such as are represented in the diagrams given in M. Polain's first pamphlet.

The curve on this page shows the gradual rise and fall of pressure produced by firing 42 grains of Schultze powder with 1⅛oz. of shot in a 12-bore barrel of 30 inches in length. But, on glancing at this diagram of increase and decrease, it must not be imagined, because the summit of the curve occurs near about midway between the points A and C, that the highest pressure also occurs about midway in the length of the barrel. The curve here depicted represents, not a measurement of *space*, but a period of *time*; and the amount of time required to propel the shot through the first two inches or so of its movement is greater than that occupied in its propulsion throughout the entire length of the rest of the barrel.

Evidence of this fact was afforded in the course of a lecture delivered by Mr R. W. S. Griffith before the Gunmakers' Association, nearly two years since, and reported in the *Field* of July 4, 1896. Particulars were there published of the time taken in travel of shot in a 12-bore barrel, at various points, by a Smith chronograph, several kinds of

powder being used, both black and nitros. With Schultze the time records were:

From cap to 3-inch plug	·00275 second.
Total time in 30-inch barrel	·00500 ,,

Hence the time of movement throughout the last 27 inches of the barrel amounted only to ·00225sec., or ·00050sec. shorter time than was required for the movement to the first plug—which movement (allowing for the length of the shot-charge and wads) may be taken approximately as covering a space of about two inches. Consequently the *space* represented by the time register from B to C would be equivalent to about a dozen-fold as great a distance as that between A and B, and the decrease of pressure would be correspondingly gradual in proportion.

We think we have said sufficient to show that there must have been some errors in the records published by M. Polain in his first pamphlet, either through defects in the apparatus or through want of sufficient care in its manipulation. In the experiments carried out at Messrs Muller and Co.'s works, the results were very different from those recorded in the previous experiments at Liége. We do not believe that these differences of result were caused by the various powder manufacturers having altered the character of their products. We think it much more probable that there have been changes either in the construction or the manipulation of the apparatus. The Polain gauge, as a piece of mechanical designing, we consider defective, and the copper crushers differ in size. Those with which we were supplied varied from 4·87 to 4·89 millimetres in length and from 3·00 to 3·02 mm. in diameter; and differences such as these will probably account for some of the irregularities from plug to plug which are found in successive rounds in the tables printed above. Considering, too, the infinite amount of care and trouble requisite to get these niggling little copper cylinders into their proper places, we should not be surprised if the whole of the extraordinary results set forth in M. Polain's first pamphlet were due to some undiscovered irregularities in the apparatus, or the manner of its working.

(*Field*, Feb. 19, 1898; Vol. 91, p. 273.)

In the *Field* of Feb. 5, 1898, we gave the results of a number of experiments carried out by ourselves in a new pressure-gauge invented by Mons. Polain, the Director of the Government Proof House at Liége, in Belgium, and compared these results with those obtained and published by M. Polain himself in Liége. The records were widely different; for whereas M. Polain obtained extraordinarily high pressures at the forward end of the gun—sometimes even in excess of those obtained at the breech—we were unable in a single instance, using the same kind of powder (Schultze of 1896 issue) to obtain any indication of high pressures in the forward portion of the bore.

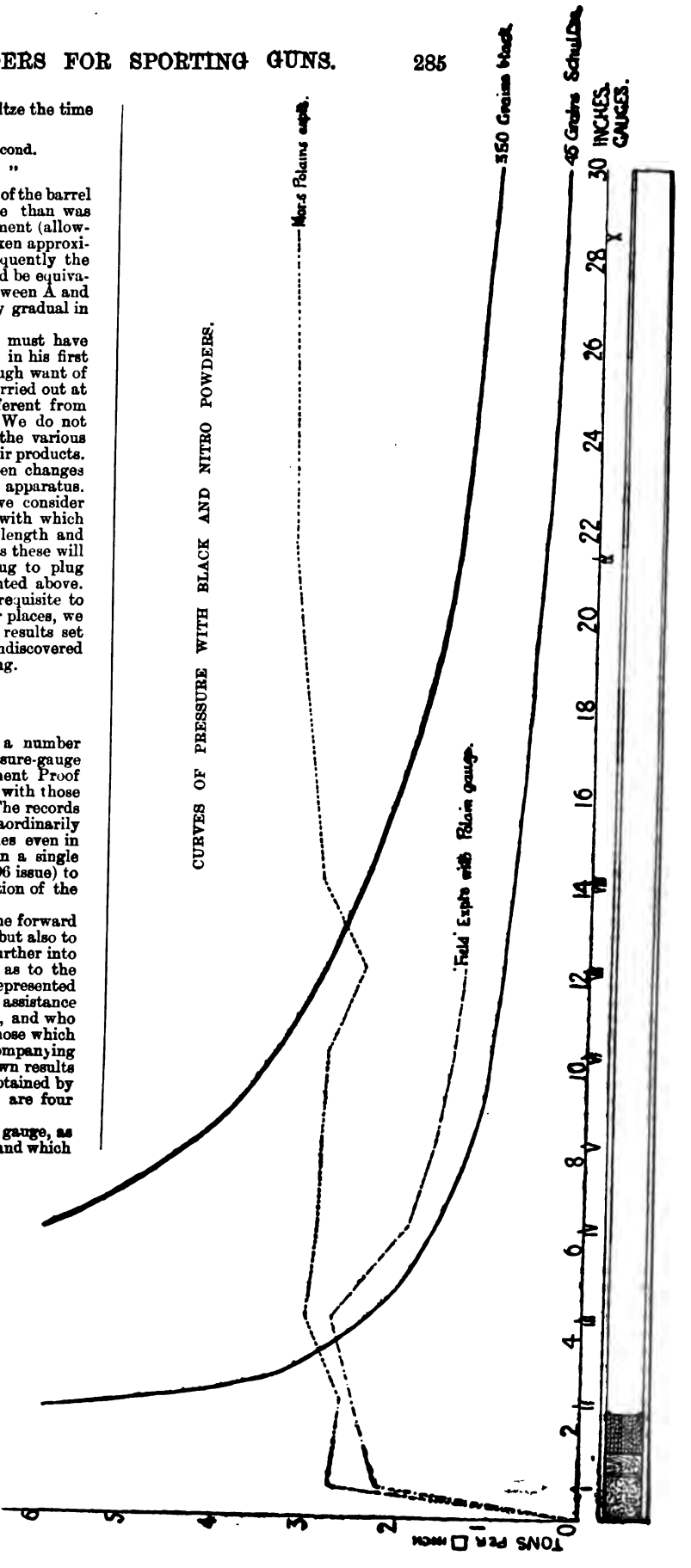
As this question of high pressures at the muzzle and in the forward portion of the barrel is of interest, not only to gunmakers, but also to the users of guns, we have thought it worth while to go further into the matter, and allay any apprehension that may exist as to the possibility of the pressures being such as M. Polain has represented them. And with this object in view we have requested the assistance of a military officer, who is a high expert in these matters, and who has carried out experiments of a different character from those which we ourselves undertook; and he has kindly supplied the accompanying diagram of curves of pressure in the barrel, including his own results with those given by M. Polain in his pamphlet and those obtained by ourselves. It will be observed that on this diagram there are four lines of curves or zigzags:

(1) Taken from M. Polain's own records in his multiple gauge, as shown in the pamphlet which he published last year (1897), and which we noticed in our impression of Feb. 5 [see page 283].

(2) Records taken by ourselves in a Polain multiple gauge, under similar conditions, and with the same issue of powder; except that we used 45grs. and M. Polain 46grs.—a difference which is of no practical importance as affecting the general results.

In both the above, although the curves appear continuous, the pressures were only taken at the points where the plugs are screwed into the barrel—these points being subsequently joined by straight lines. In our own experiments, no pressures were registered beyond the seventh plug; the pressures, therefore, were lower than the gauges register, viz., 1·38 tons per square inch.

(3) Shows the maximum pressures possible at any point in the barrel using a charge of 45grs. Schultze (the weight used in our experiments), the data having been obtained from a series of experiments in a closed vessel.



(4) In a similar manner shows the maximum pressures exerted by a charge of 350grs. (*i.e.*, 12¾drs.) of the black powder ordinarily used for proof purposes—such being the charge which a 12-bore gun is subjected to in its provisional proof.

This is pretty clear evidence that M. Polain's figures are wrong, as his pressure at the muzzle, with 42grs. of Schultze, if correct, would be about three times as high as that exhibited by 12¾drs. of ordinary proof powder. There is only one loophole for escape, and that is by bringing forward the theory of local or wave pressures. But that theory is quite untenable in this instance; for, even supposing that a local pressure rising above the curve given for 45grs. Schultze could occur at one or possibly more points in the bore, it is manifestly impossible that it should occur at every plug, as M. Polain would have it do. And, furthermore, it can be easily proved that such pressures could not be obtained by any means short of arresting the movement of the shot-charge entirely—which is an equally absurd supposition.

Gunmakers and sportsmen may therefore alike rest assured that M. Polain's pressures at the muzzle do not exist in reality, and are the result, as stated in the previous article, of some undiscovered irregularities in his apparatus or its manner of working.

The curve of pressure with the provisional proof-charge of 350 grains of proof powder (black) is of interest, as it shows that there is a large margin of safety with what may be termed a high service charge—the normal charge in a 12-bore gun with Schultze being 42 grains instead of 45; and, as stated above, the curve shown on the diagram represents "the *maximum pressures possible* at any point in the barrel using a weight of 45 grains Schultze."

With regard to "wave pressures" we may add that in all our numerous experiments with small arms we have never been able to discover them. In the diagram we gave, on the 5th inst., of the curve drawn automatically by the force inside the barrel, it will be noticed that the pressure rises very gradually at first to its maximum point, and then gradually declines—to our mind, conclusively showing that no wave action takes place in the barrels of small arms; as this curve is a typical one, selected from many hundreds of trials. If waves of pressure existed in a gunbarrel so as to give high muzzle pressures, the waves would be reflected from the shot charge back towards the breech, and would cause a serrated line to be drawn on the smoked drum instead of a fair curve.

While on the subject of crusher-gauges, we will endeavour to remove a misconception into which every authority wherewith we are acquainted has fallen. We allude to pressures being frequently given something like the following: At 1in. from breech, 2 tons; at 2¼in., 2¼ tons; here it will be noticed that there is a greater pressure at 2¼in. than there is at 1in., although there is only a distance of 1¼in. between them. This we believe to be simply impossible, because whatever pressure is experienced by the second plug must also be felt by the first; and, therefore, any excess of pressure indicated by the second crusher over that shown by the first is a false quantity. The reason that the crusher is occasionally shortened to a greater extent at the second plug, and sometimes further up the barrel, is, in our opinion, due to the pressure being applied more slowly at the first plug than it is at subsequent ones. When a metal cylinder or "crusher" has been gradually squeezed down, it offers more resistance than one which has not been thus reduced in length. Hence, when a succession of plugs are open to movement, and the powder is slow in combustion, the pressure on the first metal cylinder lasts for a much longer period of time than it does on the second, whereby the former is crushed down to a certain extent before the gas reaches the next plug. When it does so, its action is so sudden that it produces greater effect upon the second cylinder than it does on the first, although (both being in the same closed chamber) they must necessarily be submitted to an equal amount of force.

THE PHYSIOLOGY OF SHOOTING.

By WM. JAS. FLEMING, M.D.

(*Field*, Feb. 19, 1887; Vol. 69, p. 242.)

It is universally admitted that good shooting depends less upon the gun than upon the man behind it. The gun and all connected with it have received, and still receive, most minute and careful study; but little attention has been devoted to the human element in marksmanship. In so far as shooting goes, the man is as purely a machine as the gun, but a much more complicated and less understood piece of mechanism, and, to make the problem worse, an individual mechanism—no two quite alike. There are, however, some principles and arrangements common to every human shooting machine which can be formulated, and in this paper I will try to place them as clearly as possible before my readers. For this purpose it will only be necessary to consider the problems connected with shooting at moving objects, as this embraces all the questions arising out of target practice.

To begin with, let us try to analyse the processes which result in a bird coming down a few yards from where it rose near a good shot. First, he sees the bird—that is to say, the image of the bird is sharply focussed on his retina by the proper adjustment of the internal mechanism of the eye. In this retina the picture thrown upon it sets up nervous changes, which are conveyed to some part of the brain, and there produce what we call vision—in reality, a change in some part of the nervous tissue of the brain. At the same time he judges the distance of the bird, and the direction and rate of its flight, by a complicated process of which more hereafter. The information thus gained is transformed at first by an effort of will, but after sufficient practice, automatically, into orders affecting nearly all the muscles of the body. He plants his feet firmly and raises his gun (for simplicity sake here we will suppose he is a shot who takes aim—a question afterwards to be discussed). Having raised the gun, he looks along it, and, I believe, by a continual alteration of the focus of his eye, sees both the sight and the bird at one time, and waits till they are in one line. Again this state of affairs is communicated to the brain by the eye, and an order sent to the finger to pull the trigger; then the mechanism is all gun. It is all done in the fraction of a second; but it must all be done, and really much more.

I must now endeavour to explain the above somewhat more fully, but will take it for granted that the reader knows enough of ordinary optics to require no more detailed explanation of how the bird is seen, only remarking that it is by no means an instantaneous process.

Seeing the bird, how does he judge its distance from him? *By the summation of the various adjustments his eyes require to make to see clearly, compared with previous experience.* The principal of these adjustments are the amount of convergence of the two eyes required to bring their optical axes to a point at the bird, and the amount of accommodation necessary to bring the image of the bird to a sharp focus on the retina. These adjustments are made by muscles both without and within the eye, and we are informed of their amount by the *muscular sense*. This muscular sense is really the keynote of the whole question, and therefore requires some further explanation.

It is not generally known that we possess a distinct power of appreciating the amount of muscular force required to perform an action, quite separate from our sense of touch. Perhaps the best way to understand this is to consider the different effects of, say, a pound weight laid upon our palm with the back of the hand resting upon the table, and the same weight lifted freely up and down, as we instinctively do in estimating weight. In the first case we feel the pressure of a cold, hard body, but, if not aided by sight, have a very faint idea of its weight; indeed, we can scarcely tell the difference between one and two pounds if the surfaces touching the palm are of nearly the same area, and if the objects are gently deposited, the eyes being shut, and the hand motionless and supported. If, however, the weights are lifted by the arm, we at once appreciate the difference. This muscular sense plays a very important part in our lives, and is peculiarly capable of training. A good example of this is the power acquired by letter-sorters in the post office to detect by the hand alone the slightest over-weight—a practised hand rarely erring. It is by this muscular sense, telling us how much we have required to use the muscles both within and without the eye, that we estimate distance.

To return to the bird, we have seen that a series of complicated processes are necessary merely to see it and judge approximately its distance; but, aided by experience, we learn by means of the same mechanism, and practically simultaneously, a great deal more about it—the angle in relation to our position at which it is flying, an idea of the pace it is going, &c. Having unconsciously, or at least apparently so, got all this information, which, of course, is largely due to practice, the brain condition thus set up induces (in what physiologists call an automatic manner) a large number of muscular actions—planting the feet, raising the gun, and, in the case of the man who aims, which we are now considering, closing one eye and bringing the other to a place in relation to the gun suitable for aligning the barrel with the bird; then information is carried to the brain that the gun is "on," and an order sent to the finger to pull the trigger.

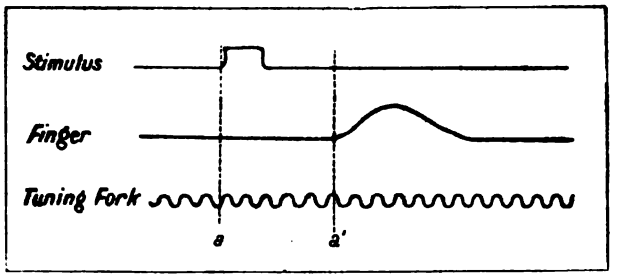
In the case of the man who shoots with both eyes open and the head erect—who, in fact, does not look along the gun at all—we have a somewhat different order of proceeding. He estimates in the same way the distance, direction, and rapidity of flight; but, having done this, trusts entirely to his muscular sense to hold the gun straight and to tell him when it is straight. To succeed in this can only be the result of practice; but we must remember that the muscular sense varies enormously in accuracy and rapidity of expression in different

men, and even in the same man at different times and under different conditions. Some men hear, see, taste, and smell better than others; why should we wonder that they differ in this sense also, or that one individual requires more training or practice to achieve the same accuracy than another?

This difference between individuals is not confined to their muscular sense, but exists in an even more marked way in the amount of time required by each to go through the complicated nervous and muscular actions which I have described. Attention was first drawn to this by the astronomers, who found that it is necessary to allow for what is called "personal error" in the observations of different individuals. For instance, suppose it is required to observe the exact moment at which a star touches a hair stretched across the field of a stationary telescope, and that by a suitable arrangement two observers are enabled to watch through the telescope at the same time—it will be found that an appreciable difference exists in the record of each. What is more, this difference will be practically constant for the same individual, constituting his "personal equation," which has to be allowed for in subsequent calculations. By modifications of this idea, physiologists have succeeded in measuring, not only the time taken by the whole process, but the time occupied by each of its component parts.

To go into the details of these experiments is needless here, but, in order to give a general idea of the methods employed, it may be well to describe one or two of them. Let us take first the one which has been perhaps best worked out—the determination of the rapidity with which an impulse travels along a nerve. If we arrange a stimulus—most conveniently an electric shock—so that when applied (let us suppose over a nerve in the forearm), it causes a contraction of the muscles of a finger, and consequently a movement of the finger; and if we measure the exact time which elapses between the electric shock and the movement of the finger—first when the stimulus is applied, say, nine inches from the finger, and again three inches from the finger—the difference will give us the time taken for transmission through the six inches, and therefore the rate.

Some of the readers of this article may be interested in the apparatus employed in making these delicate measurements, so I will briefly describe the essential features. We require a surface moving rapidly and regularly, upon which a faint motion can easily make a mark. This is generally obtained by a large cylinder rotated by clockwork, and covered with smoked paper. Upon this are inscribed, by light contact, motions, however slight, communicated to levers



APPARATUS FOR MEASURING THE RAPIDITY OF TOUCH, OR "PERSONAL EQUATION."

For the experiment just mentioned, to determine the rapidity of transmission of nervous impulses, three of these levers would be required—one attached to the finger to be moved, one actuated by the same electric current which gives the shock, and one connected with a chronograph, or instrument for marking time. This is generally a tuning fork, the number of whose vibrations is known, and of course constant. If, then, with the three levers adjusted to write exactly perpendicular to each other, the cylinder is rotated, we shall have three straight lines drawn. If now, the tuning fork is made to vibrate, the lever attached to it will mark curves, and if, now, the electric shock is sent into the nerve, the lever connected with it will move and mark the exact moment of stimulation. As soon as the muscles of the finger begin to respond to the stimulus, the lever attached to the finger will mark, and the difference between the two, read by the vibrations of the tuning fork, which have been going on all the time, gives the time of transmission. Our tracing then will be something like this, and the distance between the lines a and a', read on the tuning fork the actual time of nervous transmission less the latent period of the muscle, which we need not consider in this case. By this experiment, more or less modified, it has been calculated that the rate of transmission of motor stimuli in man is only 120 feet per second. Your readers will remember that shot at 40 yards travels at the rate of about 600 feet per second.

To estimate the time taken by the whole process for the conversion of a visual image into a voluntary muscular action—which is exactly what takes place between seeing a bird and pulling the trigger—a slightly different arrangement is required. The person to be experimented upon is seated with his finger on an electrical key, so arranged that the moment it is depressed a mark is recorded upon the revolving cylinder. A blue and red light are fixed so that either can be shown at the option of the experimenter. The subject of the experiment is directed only to depress the key when one of those lights is shown, and the instant at which this light is exposed is also recorded upon the cylinder. A chronograph is used as before. By this means we are able to estimate the whole time taken by both the nervous transmission and the mental judgment of which of the two lights was shown.

The result of a number of experiments on these lines give for different individuals from $\frac{1}{100}$ of a second to $\frac{6}{100}$ of a second. Now, if we consider that this corresponds to the interval between the gunner seeing the bird and pulling the trigger, we can easily calculate that if the bird is crossing at the rate of 50 feet per second—practically thirty-four miles an hour—in the case of a man with $\frac{1}{100}$ of a second personal error it will only have flown 6 inches, whereas in the case of the man with $\frac{6}{100}$ it will have flown 3 feet. This seems largely to explain why men differ so much in the amount they borrow. The lesson is that each individual must find out the proper "borrow" for himself, as another person, with probably quite a different personal error, cannot guide him.

A great deal has been written in your columns on two methods of borrowing, which I may summarise as "swing" and "carry forward." Upon this also the above considerations may throw some light. By "swing" I understand keeping the gun moving with the object for a short time before firing. Your correspondents are not at one about this, it appears to me, because they do not consider what is taking place during the time between the determination to pull and the explosion of the powder. If during this interval the swing is arrested (as I fancy it often is), then the gun must be pointed considerably in front of the object; but if it is kept up (that is to say, if the gun is kept pointed at the object until the shot has left the barrel) a very small allowance is necessary—merely the time taken by the shot to reach the object. Indeed, the swing of the gun must to some extent do away even with this, in the same way that a heavy object thrown from a rapidly moving train does not fly at a right angle to the train, but has the train's forward motion communicated to it as well as the motion of throwing, and therefore assumes the direction of the resultant of these two forces—outwards and forwards.

In what I have described as the carry-forward method of borrowing (which I conceive is less often actually employed than is supposed), the idea is to fire into the air where the bird will be when the shot reaches that place. Now, this may do for the man of very slight personal error; but for the man of great personal error it seems to me impracticable, from the immense distance it would entail firing in front. A good many who think they practise this method probably swing the gun into a position in front of the object, stop the swing, and fire. By this it is obvious that they only need to allow for the time between deciding to fire and the shot reaching the place; but a man who fires where the bird will be, without any swing, must allow for all—the time of deciding how far forward to shoot, raising his gun to that, and then the time of firing and travel of shot.

I am sorry I cannot suggest any simple means by which sportsmen could ascertain the amount of their personal error, as the apparatus I have described is not easily attainable; but perhaps some of our enterprising gunmakers might find it pay them to have such an apparatus for the benefit of their customers. I shall be glad to advise as to such an installation. I have long been of opinion that very good shots are generally men with small personal error; and such an arrangement would enable the truth of this idea to be investigated.

Another important point in connection with this matter is the influence, noticed by all observers, which food, stimulants, and sedatives, have in altering the figures for each individual. The effects vary in different persons; and this goes far to account for some men shooting better before, others after, lunch; for some men being unable to shoot if they smoke, others unable to shoot if they do not. I have tried to show that each must be a law to himself, and therefore, I trust, helped some men who have failed to get good results by following the rules of their mentors.

FRENCH EXPERIMENTS WITH SPORTING ARMS.

(*Field*, Oct. 8, 1892; Vol. 80, p. 542.)

MANY experiments have, from time to time, been carried out in England, by private individuals, powder manufacturers, gunmakers, and others, for the purpose of investigating phenomena connected with the action of explosives in sporting firearms. The Government, however, would never be likely, in this country, to incur the cost of any such investigations for the special behoof of sportsmen; our military authorities have quite enough to do to obtain votes sufficient to meet the requirements of the public service. Yet it is otherwise in France—a country where sport plays a comparatively inconspicuous part in the life of the nation. There the Government has carried out experiments with sporting arms; and we propose to lay before our readers some account of what has been done on the other side of the channel.

Some years ago a few experiments with sporting arms, for the purpose of determining various points connected with loading, the most suitable powders, &c., were undertaken by one of the officers in charge of a French gunpowder factory, in which, as some of our readers are doubtless aware, sporting powders are made, as well as those destined for war purposes—the manufacture of gunpowders in France being a Government monopoly. These experiments having for the most part been made with the older forms of explosive, it was deemed expedient by those in authority that more extensive and complete experiments should be carried out with the latest forms of explosives. This was accordingly done, and the results have been published by order of the Minister of War, who has most kindly allowed a *précis* of the more important portions of the work to be published in our columns.

In the report of these experiments, the size of bore is the subject first considered, and a table is given showing the difference of measurement that exists between the nominal and actual sizes of shot guns, from 4 to 32-bore; and these show that all breechloaders have bores smaller than their nominal diameter, and also that whilst the French 12 and 16-bores are almost exactly the same size as the English guns of these calibres, all the other sizes except the 32 are rather larger than the English.

The choke and its extent and proportions are next duly treated upon, as well as the best form of the slope joining the cylindrical portion of the bore with the contracted portion; and the parabolic curve was found to give better results than the simple cone in this portion of the bore. The experiments also showed that a steep slope combined with a relatively small amount of choke was preferable to a considerable choke and gentler slope—the reason of this being that with the former the shot are less crushed out of shape; and it is remarked that, although a gun bored thus will not give such a close pattern at a shorter range than 35 yards as another bored on the latter plan, yet at all distances beyond this the pattern will be better.

A choked rifled gun (that is, a gun rifled with straight grooves parallel to the axis, which grooves gradually get shallower till they eventually disappear altogether in the contracted portion of the bore near the muzzle) was also experimented with. The performance of this weapon was, as might almost have been expected, much inferior to the ordinary gun which is bored smooth.

In commenting generally upon cartridge cases, the advice given is to use the best quality, since those that split in the base are liable to strain the action of the gun, whilst those that fail in the walls reduce the velocity of the shot to a very considerable extent. Cases made wholly of metal are not recommended for use, except in uncivilised countries, where ordinary cases are not obtainable.

Trials with over-powder wads led to the conclusion that the wad which is best for the purpose of putting over the powder should be plastic yet incompressible; and that whilst wads made of wax and grease mixed gave the best results of all, yet wads made of felt well saturated (so as to make them incompressible) with the same mixture were more convenient to use, and nearly as efficient as the former.

The shot that is ordinarily found in commerce is known by a number which increases as the size of shot diminishes; but there is a good deal of difference in the size corresponding to this number when the shot are obtained from different manufacturers.

English made shot is usually two sizes smaller than that sold under the same number in France; that is to say, No. 6 English shot would be about the same size as No. 8 French shot.

It is remarked that the pellets themselves are seldom really spherical; and it is considered that it would be more rational to designate shot by a number corresponding with their mean diameter, or by the weight of one or a hundred pellets, than by the empirical plan now in vogue.

When a charge of shot is fired, the pressure of the powder gas, combined with the inertia of the pellets of shot in the forward portion of the charge, causes the pellets composing the rear portion of the charge to be more or less crushed or set up; the tendency being for them to fill up the spaces which existed between the pellets on account of their spherical shape. The greater the pressure and the softer the shot, the greater the extent to which this effect occurs.

There are several ways of proving that this phenomenon really takes place. One is by examining the pattern made by the charge on a tightly-stretched screen, or on soft wood, when it has been found that the proportion of pellets which are crushed out of shape or set up is much greater at the outside of the circle than near its centre; and this is the case whatever the range may be.

Evidence of the same effect may also be obtained by lining the interior of the cartridge case, where the shot lies, with stout paper, which will, after firing, show the imprint of the shot.

If shot made from pure lead be used, some 15 or 20 per cent. of the charge is crushed entirely out of shape, and as many as 90 per cent. has been found more or less set up; and, though the filling up of the interstices between the pellets with some incompressible and finely-divided material—such as flour, resin, or sulphur—decreases this crushing to a very great extent, yet this plan has other defects which counterbalance the advantages that might otherwise be obtained. About 1 per cent. of the pellets are said to be actually crushed together, and remain thus in contact during flight.

Hardened shot are better in this respect than pure lead ones; and such are generally made by alloying the lead with a very small quantity of arsenic. Small quantities of tin and antimony also serve to harden lead, and the best shot tried was the Newcastle Chilled Shot, which, the experimenters say, contained tin; though, as they say, the amount of this metal contained in the pellets is not sufficient to account for their hardness, which must be due in part to the processes employed in their manufacture.

Although, as has been before observed, these hardened shot are little set up by the pressure, yet, when fired at a velocity of 1000ft. per second or more, the outside pellets of the charge undergo a peculiar deformation owing to the friction against the surface of the bore, which wears them down, it is said, as much as one-half of their diameter. And by this action sometimes so much heat is generated as to melt the lead, which then adheres to the surface of the bore.

Various descriptions of powder, both black and nitro, and of English as well as French manufacture,* were used during the experiments in connection with normal charges and weights of shot—these being such as have been found to give the best results in practice. The effect of using small charges of shot with the normal charge of powder was to reduce the efficiency of the weapon; whereas if the weight of shot be increased, without increasing that of the powder, the former will have too low a velocity to be effective; and again, if the charge of powder be likewise increased to make up the velocity, there is considerable risk of straining the gun to an undesirable or even dangerous extent.

Such are the conclusions arrived at by the French experimenters. In our subsequent articles we shall deal more in detail with the results obtained by firing various charges from guns of different calibres—the recoil, sighting, and design—and many other points in connection with sporting guns and rifles, together with the methods by which they were arrived at. And we may also, where we think it desirable, append a few notes with reference to similar experiments that have been carried out in our own country.

(*Field*, Oct. 15, 1892; Vol. 80, p. 576.)

II.—THE MEASUREMENT OF THE VELOCITY OF SMALL SHOT.

THERE is more difficulty in measuring the precise velocity of a charge of shot fired from a gun than would appear at first sight, owing to the fact that different portions of the charge travel at different

* The present French nitro powder (introduced in the year 1890) is composed of

Soluble guncotton	28	parts.
Insoluble guncotton	37	,,
Nitrate of baryta	29	,,
Nitrate of potash	6	,,
	100	

In appearance it is of a light yellow colour, and the grains are regular and hard, averaging about 1270 to the dram. It is only half as sensitive to hygrometric conditions as the nitro powder it replaced, gives, moreover, more regular velocities and pressures, but still is affected by variations of temperature in the same manner, though not to the same extent. The increase in velocity when the powder is heated from freezing point to 86°F. is only some 6 per cent.

velocities. The various methods and apparatus used for the purpose are as follows:

First the Ballistic Pendulum, which measures the force of the blow given by the charge of shot on impact. This is the instrument actually used in the French powder factories, for testing sporting powders during and after manufacture. As its name implies, it consists of a pendulum, to the bob of which is attached a flat steel plate, which latter receives the impact of the shot, and is thereby driven through a certain arc that is automatically recorded. Knowing the arc through which the pendulum is moved, the weight of it, and that of the shot charge, the work done on the pendulum can be deduced, and also the striking velocity.

It is found that results so obtained are higher than the true ones. This may be explained by the fact that the gases from the gun affect the pendulum—which has to be placed close to the muzzle (some 6ft. away)—and that the wads, which generally weigh about one-twelfth the weight of the lead, also strike the plate and so vitiate the record. This cause of error, when known, can, however, be allowed for and the results thereby corrected.

The second method is that in general use for the measurement of the velocity of small shot, bullets, and also the projectiles fired from larger guns; and by this plan the time which the shot takes to travel a known distance or distances is measured by an electrical chronograph.

The instruments in practical use for this purpose may be divided into two classes: (1) Those in which the accelerating force of gravity, acting upon a mass of metal in the form of a rod falling freely in air, is used to determine the time taken. (2) Those in which a tuning fork is used to register the relation of time and space upon a moving surface, on which also records are made by accessory pieces of apparatus, actuated by the shot in its flight.

The records in both of the above classes of instrument are made in a similar manner. The shot is caused to break a wire, or to interrupt an electric circuit by some other means, as it leaves the muzzle of the gun. This, in the case of the Boulengé instrument (which comes under the first class), releases a rod suspended by an electro-magnet; or, in the second class of instrument, such as the Sébert velocimetre, an electro-magnetic pen is set in action, which makes its mark on the same surface as the pen attached to the tuning fork. Then when the shot has traversed the known distance it interrupts another electric circuit; this, in the case of the Boulengé instrument, causes another weight to fall and mark the falling rod before mentioned; and, with the Sébert, a second pen is set in action. The Boulengé instrument is only capable of taking the measurement of one interval of time, whereas the Sébert will take a number of successive records, according to the number of interruptors and pens. For the details of these instruments and the manner of using them we must ask our readers to consult the special works devoted to their description, &c.

The interruptor at the muzzle of the gun generally consists of a piece of copper wire stretched across it, so as to be cut by the shot. The interruptor at the distant point, on the other hand, is generally a sheet of steel, which has fastened to it an inertia apparatus, breaking the circuit when the shot strikes the plate. As might be expected, the design of such an apparatus and the conditions of its use must be carefully considered, otherwise the records would be quite unreliable. For instance, when using medium shot, it should not be placed farther than 60ft. from the gun, nor nearer than 30ft. to it. If the plate be placed much nearer to the gun than 30ft., say 10ft. or 15ft. for instance, there is considerable danger of its being moved by the blast before the shot reaches it; whereas, if it be placed at a distance of over 60ft. from the muzzle, one is very liable to measure the velocity of the sound wave produced by the report instead of the velocity of the shot itself, since at any range of more than about 60ft. the velocity of sound* is usually greater than the mean velocity of the shot. To avoid this the interruptor plate should, if placed at any distance less than 100ft., not be too sensitive in its action, which object may be attained by making it from ¼in. to 1in. thick. Such a plate will act without loss of time when struck by a single pellet weighing less than half a grain, if travelling at a velocity of from 600ft. to 1000ft. per second. If the distance be greater than 100ft., the best thickness for the plate is from $\frac{1}{10}$in. to $\frac{1}{5}$ in. The area of the plate should be suitable to the conditions of the experiments.

The third method of taking the velocity of charges of shot is by means of an apparatus devised by Messrs Billardon and Don some time prior to 1882.† This ingenious instrument consists essentially of two circular screens, the one about five times the diameter of the other. The smaller one of the two is practically a circular hole in a wooden framework erected in front of the larger one, and across this circular space is stretched a thin piece of paper through which the shot pass, leaving, of course, a pattern on the paper where they passed through. Seven or eight inches further away from the muzzle of the gun is the larger screen, which revolves. This screen has a surface on which the point of impact of each pellet of shot is separately recorded; and an electrical instrument, fixed in rear of the screen, marks on the reverse side of it the instant when the shot left the muzzle; and it also makes another record, from which the velocity that the screen was then revolving at can be directly ascertained.

With this information, the revolving screen can be placed in the exact position it was in when the shot left the gun: and by superposing the records on the fixed and revolving screen, the velocity of every pellet that struck both of the screens can be separately determined.

* The velocity of sound is not less than 1100ft. per second.

† A somewhat similar apparatus to this, due to Mr Griffith, was fully described, and the details of some very interesting experiments carried out with it were given, in the *Field* on April 9, 1887, and are here reprinted at pp. 49 to 59.

(*Field*, Oct. 22, 1892; Vol. 80, p. 611.)

III.—MUZZLE OR INITIAL VELOCITY.

If the muzzle velocity (or, as it is frequently also called, initial velocity) of a charge of shot or of a bullet fired from a gun be known, and also the loss of velocity occasioned by the resistance of the air, the remaining velocity at any given range can be determined, and from this the killing power of the weapon can be ascertained. Thus we see that a knowledge of the value of the muzzle velocity imparted to various weights and sizes of shot by different charges of powder may be of considerable value not only to the gunmaker, who designs guns and loads cartridges for special purposes, but also to the sportsman, who desires to make the most of his gun's powers.

Although the muzzle velocity in a given gun with a given charge of powder and shot will vary to some extent (as we shall explain subsequently) with the method of loading, the temperature, and from a number of other causes, still, the value that it will have under ordinary conditions can be very closely calculated, probably within much smaller limits than are required in actual practice. The greater part of the French experiments to determine the muzzle velocity with varying charges of powder and shot were carried out in 12, 16, and 32-bore central-fire guns, and cases loaded in the usual manner were employed.

It may be of interest, perhaps, to give a few details of these guns and the cartridges used.

Nominal Calibre.	Diameter of Bore.	Diameter of Choke.	Length of Barrel.
12-bore choke.....	·724	·708	30in.
16-bore cylinder	·669	—	30in.
32-bore cylinder	·508	—	27·6in.

The cartridge cases were the ordinary ones of commerce, with paper bodies. The black powder was made in the State Factory at Sevran-Livry; the wads over the powder were thick felt ones, saturated with a mixture of wax and grease placed between two grease-proof card wads; a thin card wad was placed over the shot charge, and the case was then well turned over. The loading with bullets* was the same, as far as the powder was concerned, but they themselves were fixed in position by the mixture of wax and grease being poured over them into the case; the cases were not turned down. Great care was taken in weighing the charges, which were all correct to ·15gr., and the difference between the nominal and actual weight of the shot never exceeded half the weight of a single pellet.

It has become the custom of late years, both at home and abroad, instead of compiling tables to show the relation existing between cause and effect as it were, to depict their values in a graphical form, thereby appealing more quickly and directly to the senses.

The graphical diagrams in Figs. 1 and 2 (next page) respectively represent the relation existing between the weight of the charge of black and nitro powder† in a 16-bore gun, and the muzzle velocity imparted to the shot, the weight of the charge of shot used being 1·058oz., and its size No. 6 (French). The No. 2 ordinary black powder used is said to be similar in its powers to that of Curtis and Harvey's manufacture bearing the same number.

* Composed of lead hardened with 5 per cent. of antimony.

† This diagram represents the value in the winter, when the temperature was low.

Since the proportions existing between the dimensions of ordinary shot guns themselves, and the relative weights of their normal charges of powder and shot, vary but little, it is obviously possible to make out a table of multipliers or factors; so that if the charge of any one calibre giving certain ballistics is known, the weight of charge necessary to produce the same muzzle velocity and pressures in another calibre can be at once determined. Such a table we give below:

Nominal calibre	4	8	10	12	16	20	24	28	32
Weight of shot, ounces	3·685	2·116	1·630	1·368	1·058	·8451	·709	·599	·4586
Factor	2·94	1·84	1·47	1·25	1	·823	·708	·607	·48

By the use of this table we can determine the charge to give any velocity between the limits of the diagrams, in any of the guns with the normal weights of shot laid down, by simply multiplying the weight of the charge that gives the required velocity in the diagram of the 16-bore, by the factor that is under the head of the particular calibre of gun we are dealing with.*

FIG. 1.

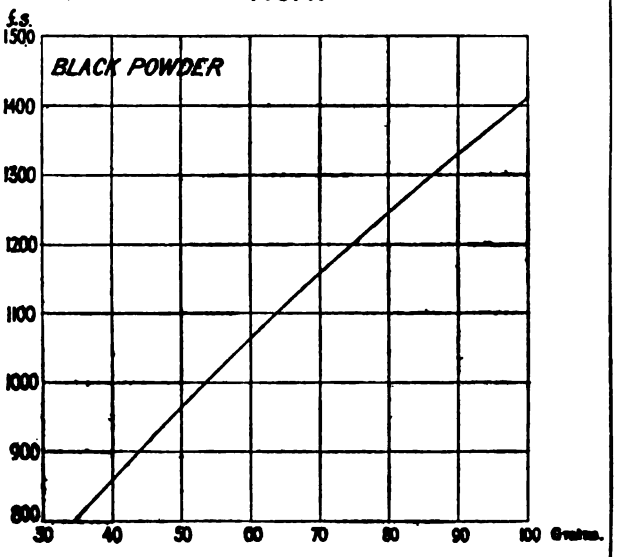


TABLE OF COMPARATIVE DIMENSIONS OF ENGLISH AND FRENCH GUNS, ALSO WEIGHTS OF BULLETS.

Diameter of Bore in Inches.

	4	8	10	12	14	16	20	24	28	32
Exact diameter according to French nominal calibre †	1·0778	·8543	·795	·748	·71	·6811	·632	·594	·565	·539
Measurement of English gun	1·052	·835	·775	·729	·693	·662	·615	·579	·550	·526
Measurement of French gun	1·023	·8504	·779	·732	·693	·673	·636	·590	·559	·511

Normal Total Length of Barrel in Inches.

English ‡	34	32	30	30	30	30	30	28	26	24
French	—	32·28	30·11	29·92	29·92	29·92	28·74	27·56	26·77	26·77

* It must be remembered that the sizes given are the French, not English, ones. The relative dimensions and weights of bullet are given in the subjoined table:

† Calculated on the basis of the old French pound weight, which contained 489·5 grammes (*i.e.*, 16·991 English ounces), the numeral denoting the calibre represents the number of spherical bullets of lead, of specific gravity 11·35, weighing 1lb.

‡ These are merely stated as approximate, and as possibly representing the majority; but there are very great differences—*e.g.*, 12-bores vary in length from 28in. to 32in., although the great majority are 30in.

Diameter of Chamber in Inches.

	4	8	10	12	14	16	20	24	28	32
English *	1·037	·915	·838	·800	·764	·730	·690	·650	·618	·567
French †	—	·941	·846	·807	·767	·748	·689	·649	·618	·571

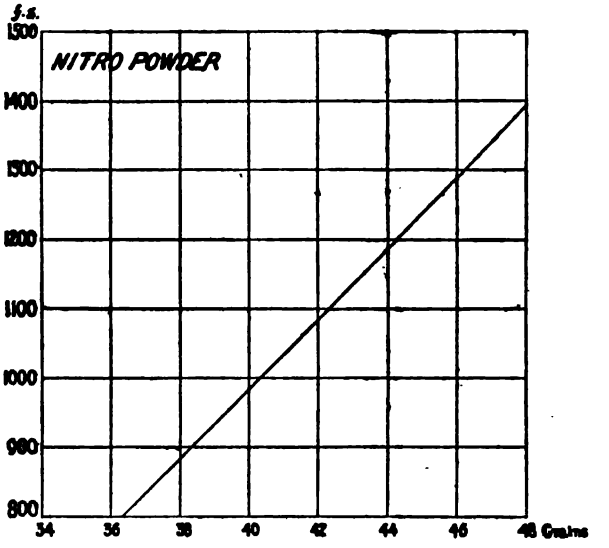
Weight of Bullet in Grains.

English	1750	875	700	588	500	437·5	350	294	250	218·75
French	1612	925	712	599	500	458	360	310	262	208

But we can go even further than this; for within certain limits (within, say, 25 per cent. the normal weights) the proportion of weight that the powder bears to the shot has a close relation to the muzzle velocity; and, consequently, if we know the results in one calibre, when the proportion of the weight of the powder to that of the shot is varied, we shall be able to determine within near limits the results obtainable in other calibres.

Fig. 3 shows a curve made on the results of varying the weights of powder and shot in a 16-bore gun, and gives the muzzle velocity

FIG. 2.



which will be obtained when the weight of the shot charge is varied from four times that of the powder (black) charge to eleven times its weight.

The muzzle velocity when a bullet is substituted for an equal weight of shot is generally about 100ft. higher than that imparted to the shot under the same conditions of charge—that is, when a quick burning powder is used; but when a slow-burning description is employed it is practically the same as that of the shot, with the full charge, but it is greater with smaller charges, the difference increasing as the charge diminishes.

The nitro powders do not give regular results when used with bullets.

We have now, with the diagrams and the table of factors, all the data necessary for the determination of the powder charge to give any velocity to any weight of shot, within practical limits, in any calibre of gun, provided that the 25 per cent. on either side of the normal weights be not exceeded.

In order to ascertain what difference, if any, there was between the English trade powders and the French Government's nitro powder, a number of rounds were fired from a 12-bore choke and

* These are the measurements required for the admission of the paper body of Messrs Eley's cartridges; and we believe the cases made by other English manufacturers very closely resemble them in size. Some gunmakers, however, make the chambers of their guns slightly larger than those of other gunmakers.

† The slope connecting the chamber and bore varies from ·393in. to ·56in. in length.

16-bore cylinder gun respectively, and the mean results are given tabulated below:

Calibre of barrel.	Description of barrel.	Description of Powder.	Weight of Powder.	Weight of Shot.	Muzzle Velocity.	Temp. of Air.
12	Choke	E.C.	42·3grs.	1·128oz.	1125 f.s.	33·8° F.
,,	,,	Schultze	,,	,,	1332 f.s.	,,
,,	,,	French nitro	,,	,,	1194 f.s.	,,
16	Cylinder	E.C.	37·03grs.	1·058oz.	931 f.s.	37·4°
,,	,,	Schultze	,,	,,	1090 f.s.	,,
,,	,,	French nitro	,,	,,	944 f.s.	,,

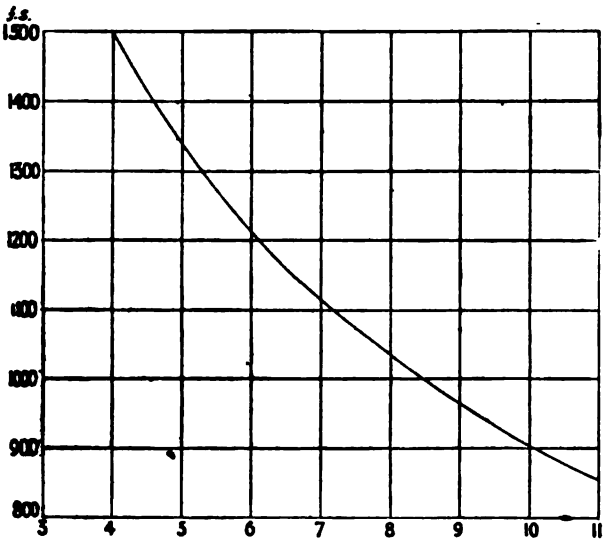
Such are the results set forth in the official report to the French Government on this subject.

(*Field*, Oct. 29, 1892; Vol. 80, p. 681.)

IV.—REMAINING AND TERMINAL VELOCITIES.

By the "remaining velocity" of a projectile is meant the velocity that is left in it at any definite point of its trajectory; and, since it is the value of this velocity that determines its killing power, it would seem indispensable that the remaining velocities of different charges and sizes of shot, as well as of bullets, should be accurately known under the various conditions that occur in practice.

FIG.3.



It will be readily understood that it is far easier, both in theory and practice, to ascertain the remaining velocity of a bullet than to determine that of a charge of shot, whose pellets travel a short and variable distance from the muzzle of the gun practically *en masse*, or as a single projectile of more or less cylindrical shape, and then disperse gradually, until they become separate and spherical projectiles. The remaining velocity of a bullet, whether of spherical shape or otherwise, can be readily and accurately calculated, if its muzzle velocity be known, by means of Professor Bashforth's tables*; but the impossibility of applying the same method to the velocity of a shot charge was gone into in a very complete and exhaustive manner in the *Field* of Dec. 29, 1888.

Although, however, theory fails, it is possible to lay down empirical values based upon actual experiments for the relation between muzzle and remaining velocities; this is what the French have very carefully done, by the compilation of many results obtained by different methods and several different sorts of instruments.

By one method the remaining velocity was obtained by a chronograph in a similar manner to the muzzle velocity—that is, by measuring the time taken by the charge in travelling between two points, dividing this space (in feet) by the time (in seconds), the result being the velocity (in feet per second) at a third point midway between the other two. Such a method is very approximately correct when the loss of velocity between the two extreme points does not exceed 150 f.s.

The Boulengé chronograph is, as explained in our second article, only capable of taking one time record; and therefore the arrangement of muzzle wire and screen, or interrupter plate, has to be modified in order to enable remaining velocities at all ranges to be taken with accuracy. To do this, two interrupter plates, placed about 30ft. apart, were connected with the chronograph, and they were placed in *échelon* as regards the gun, so that each one received its own half of the charge of shot, the charge being directed on the visual vertical line corresponding with the junction of the inner edges of the two plates. By this plan the remaining velocity at the middle point between the interrupter plates was obtained.

Another method was employed with the Sébert tuning-fork chronograph—an instrument with which a number of successive time records can be obtained. In this case a muzzle wire cut by the charge leaving the muzzle formed the first record, and three or more interrupter plates—placed one above the other instead of in *échelon*—were used to obtain successive records on the trajectory. From these records a curve was constructed to show the remaining velocity at any point.

The experiments were made with cylinder guns, as it was found that the difference between the velocities of the pellets in the front portion of the charge in a choke-bore gun and those in the rear was very considerable, and consequently the results were not so trustworthy as they were when the cylinder gun was employed.

As some of our diagrams will necessarily refer to French sizes of shot, whilst others may apply to English numbers, we give a table showing the relation between them:

TABLE GIVING COMPARATIVE DIMENSIONS OF ENGLISH* AND FRENCH SHOT OF VARIOUS SIZES.

French Sizes.	Diameter in Inches.	Weight in Grains.	Weight in Grains.	Diameter in Inches.	English Sizes.
OO	·2668	13·63	10·94	·197	AAA
	—	—	9·11	·185	AA
O	·1755	8·10	7·81	·176	A
	—	—	6·84	·168	BBB
No. 2	·1535	5·40	5·76	·159	BB
	—	—	4·97	·151	B
	—	—	4·21	·143	No. 1
No. 4	·135	3·64	3·77	·138	No. 2
	—	—	3·12	·129	No. 3
No. 6	·119	2·51	2·54	·120	No. 4
	—	—	2·01	·112	No. 5
No. 8	·106	1·71	1·62	·103	No. 6
	—	—	1·29	·094	No. 7
No. 10	·087	0·98	0·97	·086	No. 8
	—	—	0·748	·0787	No. 9
No. 12	·0591	0·306	0·509	·0692	No. 10

Fig. 10 shows what the remaining velocities of three different sizes of shot will be, at increasing distances from the muzzle of the gun, when the muzzle velocity is 1470ft. per second; and from it also can be deduced what the remaining velocity will be when the muzzle velocity is lower than 1470 f.s., in the following manner. Supposing we desire to know the remaining velocity of a charge of shot, the pellets of which weigh 5·77 grains each (and therefore similar in size to English BB shot), at 150ft. from the muzzle, where the

* "The Bashforth Chronograph" (published by the Cambridge University Press, 1890).

* The weights and measurements of the English sizes of shot are taken from those made by the Newcastle Chilled Shot Company. The shot made by other English manufacturers vary more or less from the above standard.

velocity is 1100 f.s. Referring to our diagram (Fig. 10), we find that 1100 f.s. nearly corresponds with a distance of 50ft.; to this we add the 150ft. range, and then the intersection of the 200ft. range with the line corresponding to the 5·77grs. pellet gives us 600 f.s. as the remaining velocity.

FIG. 10.

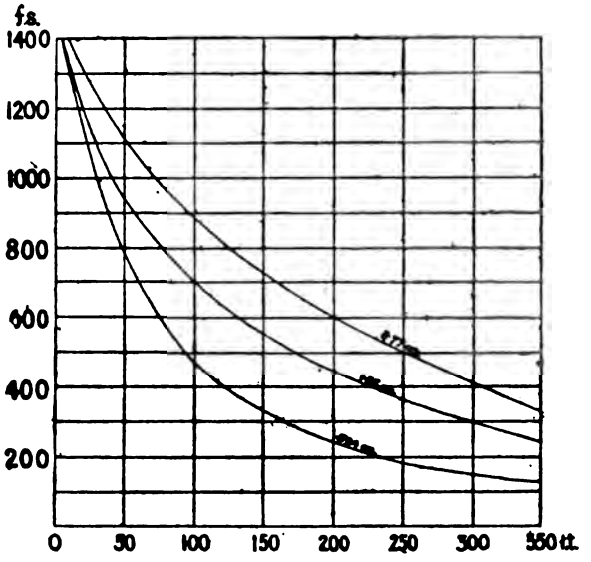


Fig. 11 conversely gives the amounts in f.s., K, to be added to the remaining velocities observed at 16·4ft. from the muzzle (which is equivalent to five mètres, the distance at which measurements of velocity are most conveniently made) with various sizes of shot, in order to obtain the corresponding muzzle velocity.

FIG. 11.

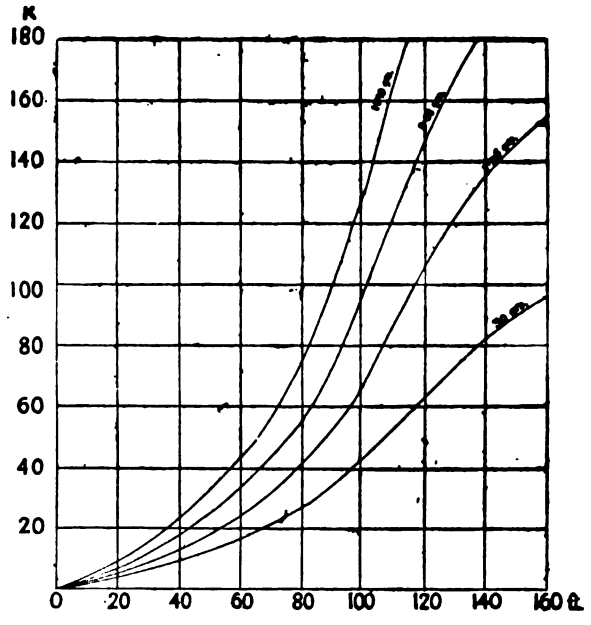


Fig. 12 gives the results obtained from some experiments carried out by Mr. R. W. S. Griffith with a similar object, and recorded in the *Field* of Dec. 29, 1888. This diagram shows the remaining velocities up to 90ft.; the upper line being that due to a charge of 1oz. of No. 6 shot fired with 3drs. of powder from a 12-bore gun, whilst the lower one is due to a charge of 1¼oz. shot with the same weight of powder.

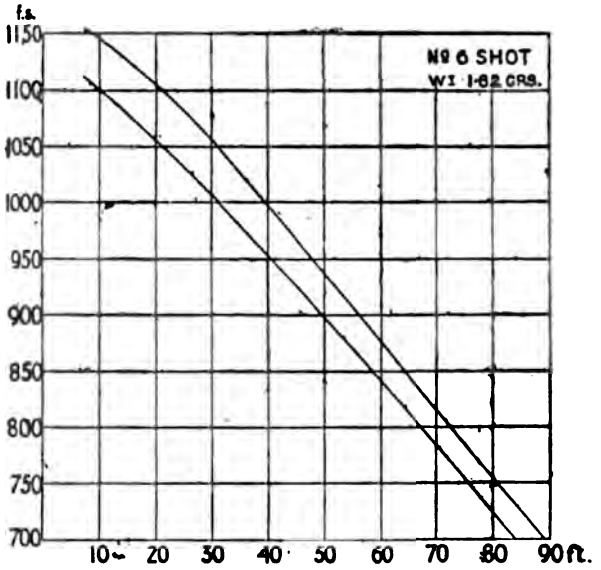
Fig. 13, deduced from diagrams 10 and 11, shows how far a charge of shot, starting with a muzzle velocity of 1150 f.s., will travel before its velocity is reduced below the limits shown by the radiating lines. For instance, let us suppose it is required to know how far a charge of No. 6 shot will travel before its velocity is reduced to 500 f.s. The process is as follows: Find the intersection of the horizontal line representing No. 6 shot with the radial line representing 500 f.s., and then draw a vertical line through this point and the scale of feet along the lower edge of the diagram—this gives 140ft. as the distance from the muzzle where the remaining velocity will be 500 f.s.

It is sometimes useful to know the "Terminal Velocity"* of various sizes of lead shot and bullets, and we therefore give the approximate values for a few sizes, from which others can be easily ascertained.

No. 8 shot	92 f.s.	20-bore bullet	240 f.s.
„ 6 „	100 „	16 „ „	250 „
„ 4 „	116 „	12 „ „	275 „
„ 2 „	120 „		

In practice the above velocities are very nearly attained by the falling pellets whenever the gun is fired at an elevation of over 10°.

FIG. 12.



The maximum range of a spherical leaden projectile is obtained when it is fired at about 32° elevation. The experiments carried out to determine the maximum ranges with shot and bullets showed that, whilst the maximum range of No. 6 shot (fired with usual charge) was as much as 800ft., yet it would not cause injury (except to the eyes) at any distance beyond 330ft. On the other hand, a pellet whose diameter exceeds ·2in. (or AAA shot) has sufficient velocity at its maximum range to penetrate a man's skin; whilst a 16-bore bullet, whose maximum range is some 3900ft., would produce a serious wound at that distance.

(*Field*, Nov. 12, 1892; Vol. 80, p. 757.)

V.—CAUSES OF VARIATION IN VELOCITY OF SHOT.

THE velocities hitherto discussed in these articles have been those of the effective shot-charge, and not the velocities of the individual pellets composing the charge. Although all the pellets may leave the muzzle of a cylinder gun with practically the same velocity, neverthe-

* This is the maximum and uniform velocity which a projectile attains when falling in air, which occurs when the accelerating action of the force of gravity is balanced by the resistance of the air.

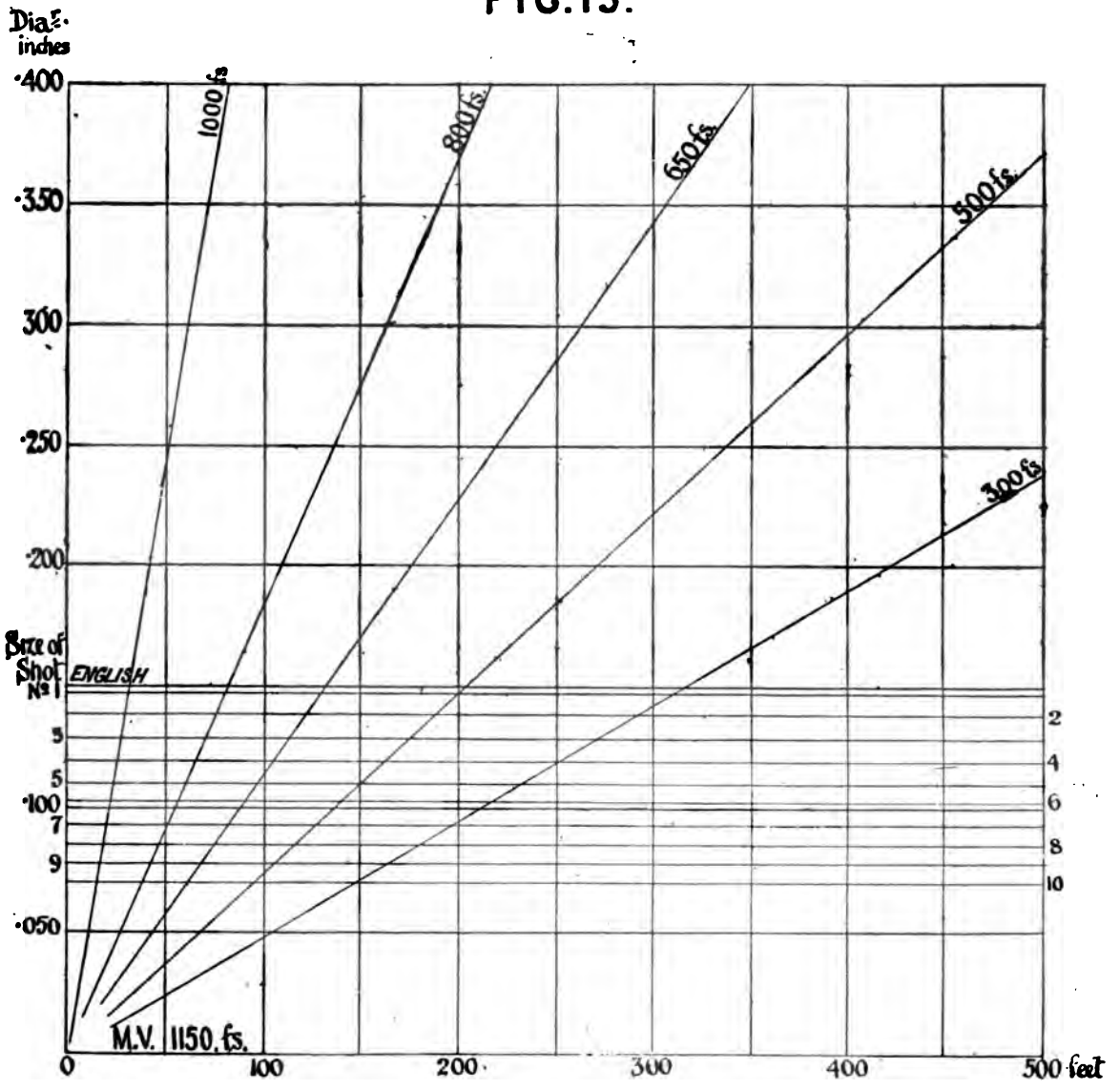
less they will be found to sustain unequal losses in their passage through the air, owing to slight differences in their shape, reactions upon one another, and various other causes.

Experiments to test these points were made with Billardon and Don's revolving chronograph, and showed, for example, that with a charge of No. 6 French shot (equal to No. 4 English) at 98ft. from the muzzle the mean velocity was 872 f.s. But the mean difference in velocity of individual pellets from the above number (872 f.s.) was 28 f.s., whilst the *maximum* difference rose to as high a figure as 130 f.s. The differences went on increasing rapidly with the range.

As we briefly stated, when considering the subject of Muzzle Velocity, there are a number of causes which may produce a more or less considerable variation from the normal. These may be classified under five heads, A, B, C. D, and E. The five heads may then be further subdivided, as follows :

A. *Variations due to the powder*, by
1. Influence of temperature upon it.
2. Influence of moisture.
3. Ramming.

FIG. 13.



Variations of this kind can be easily detected by the ear, by placing oneself behind a vertical target at a range of over 60 yards, at which distance the arrival of the pellets one after another in succession will be unmistakably heard.

At their extreme range (that is with 32° elevation) the arrival of the pellets is spread over a time of more than one second; and it is interesting to know that a charge of No. 2 French shot (similar in size to BB English) takes as long as eight seconds during its flight under these circumstances (*i.e.*, extreme range, with 32° elevation).

B. *Variations due to the proportions of the gun :*
1. The length of bore.
2. The cylinder bore as compared to the choke.

C. *Variations due to the cartridge case :*
1. Metal cases.
2. Split paper cases.
3. Powder of the cap.
4. Cases cut round.
5. Turning over.

D. *Variations due to the nature of the over-powder wad.*

E. *Variations due to the shot:*

1. Effect of varying the size.
2. Effect of varying the weight of the charge.

A.—Variations due to the Powder.

As regards subdivision 1. The range of temperature to which powder charges may be considered to be liable to be exposed is as much as 140° Fahr.; for in summer, even in central Europe, their temperature in the sun may rise to 120° F., and in hot countries to 150° F., while, on the other hand, in cold climates they may be fired at as low a temperature as 10° (and even much lower than this in Russia). This difference of temperature has not such a very great effect on black powders, the variation in velocity not being greater than 2 per cent. for every 10° F. With nitro powders, however, the effect of a change of temperature is much more marked, for when cartridges of French nitro powder (old type) were fired at temperatures of 36° F. and 122° F. respectively, the muzzle velocity varied to the extent of nearly 18 f.s. for 10°; whilst similar trials with E.C. and Schultze showed that these latter only varied 12½ f.s. under similar conditions. In all these experiments the temperature of the chamber of the gun was made the same as that of the cartridge.

The following table gives the actual length of English guns of 42 calibres:

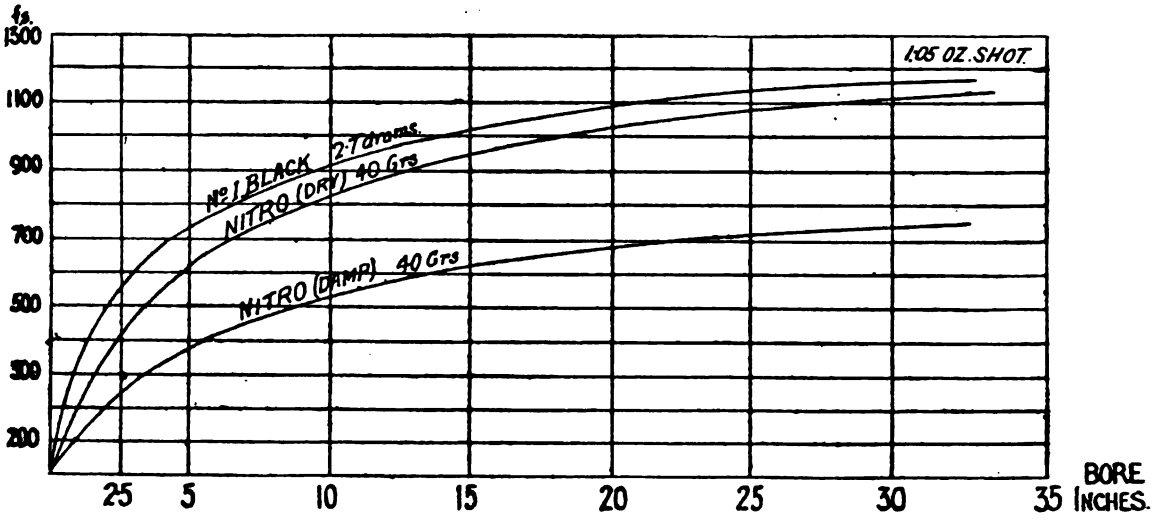
4-bore	44·2 inches.	16-bore	27·8 inches.
8 "	35·0 "	20 "	25·8 "
10 "	32·5 "	24 "	24·3 "
12 "	30·6 "	28 "	23·1 "
14 "	29·1 "	32 "	22·1 "

2. The records of the chronograph show a considerable difference between the muzzle velocity of a chokebore and a cylinder gun, using identically the same description of cartridge and charge. In the case of a 16-bore gun, which was choked to the extent of ·03937in. (1 millimetre) at the muzzle, the increase due to the choking was found to be 33 f.s. on a velocity of 1096 f.s.; and this increase was entirely independent of the sort of powder used.

With a view to investigate the reason of this increase of muzzle velocity, a 32-bore barrel was prepared, to which a muzzle portion could be affixed, with different forms, lengths, and diameters of choke, the smallest one reducing the diameter of the bore of the gun to very nearly one-half.

By this means it was proved that the velocity, as measured by the chronograph, increases with the amount of choking, and can even attain as much as 330 f.s. in 1300 f.s.; that is, an increase of 25 per cent. produced entirely by the choke.

FIG. 4.



2. The effect of moisture was found to be rather greater on the black than on the nitro powders—an increase of 1 per cent. in moisture of the powder diminishing the muzzle velocity to the extent of $\frac{1}{17}$ with black, and $\frac{1}{10}$ with nitro powder. It is remarked that powders will absorb in a few weeks as much as 4 or 5 per cent. of moisture if not properly sealed in their cases.

3. A slight amount of force applied to compress the charge when loading increases the muzzle velocity; but the velocity will not increase if a great deal more force be applied. And especial care should always be taken that the grains of powder are not crushed; for not only is this practice a dangerous one, but it actually decreases the muzzle velocity.

B.—Variations due to the proportions of the Gun.

1. Double-barrelled guns have, as a rule, barrels about 30in. long; and, to determine whether this length was the most effective, recourse was had to the records of the velocimetre.

The diagram Fig. 4 shows the velocity at which the shot is travelling at any point in the bore of a 16-bore choke gun, and illustrates also the effect that moisture has on French nitro powder in reducing its power.

The conclusion that one arrives at from these and other experiment, is that the total length of barrel of a shot gun should be from 40 to 45 calibres to obtain the most useful effect.*

The reason for this action is as follows: In a chokebore gun the whole of the charge is momentarily checked in the choke, and a portion of the *vis viva* of the rear pellets is transferred to those in front, which thus obtain an increase of velocity at the expense of those in the rear. The chronograph measures the velocity of the fastest pellet, and therefore shows an increase of velocity; but if the energy of the shot charge as a whole be measured, there is a slight decrease in the chokebore as compared with the cylinder.*

The choking of a gun should not exceed $\frac{1}{10}$ of its calibre, as there are more disadvantages than advantages in contracting a bore to a greater advantage than this.

C.—Variations Due to the Cartridge Case.

1. *Thin Metallic Case* †.—Owing to the difference in capacity between these and the paper cases and to the different conditions of the loading, frictional resistance of wads, &c., a slightly larger charge is necessary to get with such a metal case the same velocity as with a paper one.

* See the *Field* of Aug. 29, 1891.

* These results are in conflict with those of some English experiments which were detailed at considerable length in the *Field* of April 9, 1887 (here reprinted at pp. 49 to 59) and indicated that the velocity of the whole charge was higher with the chokebore. Possibly, however, this may be due to the gauge and boring of the guns used in the French experiments being different from the 12-bores used in the English experiments.—Ed.

† Vide the *Field*, Oct. 17, 1891.

2. If the paper case be split longitudinally it reduces the velocity considerably, as the gases pass the wad and enter the shot charge. The loss of velocity is generally about 150 f.s., but may amount to twice as much. The loss of velocity, if the base of the cartridge splits, depends upon the amount of gas escape.

3. The power of the cap has in itself no sensible influence on the velocity* with either black or nitro powders, but is liable, if weak, to cause hangfires, particularly with nitro powders. The latter powders generally require more powerful caps than black powders, particularly in cold weather, or if the powder has been exposed to damp and has absorbed moisture in excess of 2 per cent. Caps containing chlorate of potash should be avoided, on account of their producing rust in the gun.

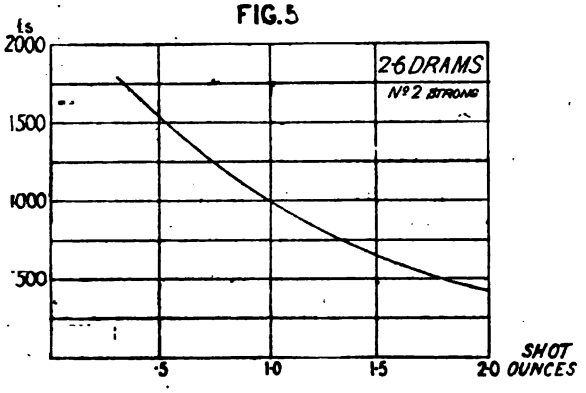
4. Cartridges loaded with black powder should be well turned over, as the velocity is thereby increased. The same remark applies in a greater degree to the nitro powders.

5. *Cartridges cut round.*—Sometimes it happens, with inferior cartridges in a greasy chamber, that the cartridge case parts, and that the portion round the shot goes down the bore with it. This causes the shot to hold together, and sometimes to kill at an extraordinary distance. If this effect be produced purposely, by cutting the cartridge before loading, the muzzle velocity will be found to be slightly reduced in a cylinder gun, whilst in a chokebore the reduction is some 60 to 130 f.s.

D.—Variations due to the Nature of the Powder Wad.

The nature of the over-powder wad has a very considerable influence on the muzzle velocity of the shot. If too thin and not plastic, it allows the gas to get amongst the shot; if soft, the powder is not confined to the same extent, and its full force is therefore not developed. All things considered, the best results are got with a hard yet plastic wad, such as one composed of wax and grease, or of felt saturated with wax or grease. The loss of velocity due to an unsuitable nature of wad may amount to as much as 350 f.s.

FIG. 5



E.—Variations due to the Shot.

1. The size of pellets has no sensible influence on the muzzle velocity, although it appears to have; for when one measures the mean velocity by chronograph at 16·4ft. (5 mètres), for instance, with the same charges, differing only in size of shot, the velocities observed will decrease with the size of the shot. This is due to the smaller shot losing their velocity much quicker than the larger. The effect is still more marked if the mean velocity be measured at twice the above distance.

2. The effect of varying the weight of the charge of shot has, of course, a great effect on the muzzle velocity. The muzzle velocity with the same charge of black powder, but different weights of shot, in a 12-bore gun, is shown graphically in the diagram Fig. 5.

(*Field*, Nov. 26, 1892; Vol. 80, p. 834.)

VI.—PRESSURES IN THE CHAMBER AND BORE.

A knowledge of the pressures exerted by the charge of explosive in the bore of a gun is almost as important to the sportsman as a knowledge of the muzzle velocity which the charge will impart to the shot—though from quite another point of view, namely, his own personal safety. Knowing the pressures exerted by the normal loads, it can be laid down to what extent in excess of this the gun should be tested before use, and, conversely, if the pressures given by the proof charge have been ascertained, then a service or normal charge can be laid down which will give a sufficient margin of safety for all practical requirements.

The details of charges of powder and shot used for the proof of sporting guns in France were therefore first obtained from the Director of the Saint Etienne Proof-House, and experiments were then instituted to ascertain what pressures the guns of various calibres were actually subjected to at proof, and how the proofs generally compared with the English and Belgian proofs.

The French proof consists of two portions:

1. The provisional proof of the finished barrel, but without the breech action—a breech plug, having a vent or touch-hole bored through it, taking the place of the breech action.

2. The proof of the gun completely mounted, with its action finished.

The powder used in the experiments was that known as Black, ordinary, No. 1 (French), which, though not identically the same powder as that used at the St. Etienne Proof-House, was almost exactly the same in its ballistic properties.

As regards the shot, some special experiments were carried out which showed that the size of the shot might be varied considerably (from No. 2 to No. 11 French, in fact) without appreciably affecting the pressures; consequently the greater number of the rounds were fired with No. 2 shot (similar in size to English BB shot).

In the subjoined tables we give particulars of the French proofs in detail, and those of our readers who wish to compare them with the English proof we would refer to our issue of Jan. 7, 1888, which contained a summary of the English Proof-House Regulations, that came into force in April, 1888.*

The pressures in the chamber, in the French experiments, were all obtained by means of a pressure or crusher-gauge apparatus, as it is usually termed, similar in all respects to that employed for determining the pressure in the French service rifle. This gauge consists of a small steel piston, one end of which is exposed to the pressure of the gases in the chamber of the gun, whilst the other end impinges upon a small cylinder of copper, which is crushed or shortened more or less according to the pressure exerted upon it. The extent of compression of this copper cylinder, resulting from various amounts of force being exerted on the piston, having been previously ascertained and tabulated, the pressures in the chamber can be deduced by measuring the extent to which the copper cylinder is compressed by the gaseous force, and comparing this with the tables of compression mentioned above.

The records of pressures in the bore in these French experiments were calculated from the records of the Sébert velocimetre employed in conjunction with guns of 16 and 32 bore calibres; and to these and the methods used in the experiments we shall refer later on.

FRENCH FIRST PROOF (CORRESPONDING TO ENGLISH PROVISIONAL PROOF).

One Round.

Calibre in inches.	Nominal calibre.	Charge.		Pressure per square inch in chamber.	Nom. Cal.
		Powder.	Shot.		
		Drams.	Ounces.	lb.	
·496 to ·527	32	3·95	1·06	19,300	32
·535 „ ·567	28	4·23	1·23	18,130	28
·575 „ ·606	24	4·53	1·41	17,140	24
·614 „ ·646	20	4·80	1·59	16,200	20
·653 „ ·685	16	5·08	1·76	15,550	16
·693 „ ·724	14 & 12	5·64	2·12	15,550	14 & 12
·732 „ ·764	12	6·21	2·47	15,550	12
·772 „ ·803	10	7·08	3·00	16,780	10
·850 „ ·882	8	9·03	4·23	17,550	8
—	4	—	—	21,120	4

*In connection with this subject see the *Fields* of Feb. 7 and Sept. 12, 1891.

* Since then some new regulations have come into force, and they are reprinted at the commencement of this work (*see* pages 2 to 8).

FRENCH SECOND PROOF (CORRESPONDING TO ENGLISH DEFINITIVE PROOF).

ONE ROUND OF EACH CHARGE.

Nominal Calibre.	Charge. Powder.	Charge. Shot.	Maximum pressure per square inch in chamber.
	Drams.	Ounces.	lb.
32	1·41	0·88	8,470
28	1·69	1·06	8,540
24	1·98	1·23	9,110
20	2·54	1·06 1·41 1·76	10,400
16	2·82	1·06 1·41 1·94 2·12	10,100
14	3·10	1·41 1·77 2·29	10,680
12	3·67	1·59 1·94 2·12 2·29	10,680
10	3·67 4·23 4·80	1·76 2·65 3·00	12,390
8	5·08 5·64 6·21	2·29 2·65 3·88	13,500

The pressures in the above tables were obtained partly from actual results of firing and partly by calculation.

The following are some of the actual results obtained by firing the proof-charges in a 16-bore gun:

Powder charge. Black No. 1 ordinary.	Shot.	No. of rounds fired.	Mean pressures in chamber, lb. per. sq. in.	Remarks on loading.
Drams.	Ounces.		lb.	
2·82	1·06 No. 2	5	6,980	One greased felt wad over the powder, and a similar wad over the shot.
"	1·41 "	5	8,280	
"	1·94 "	5	10,100	
"	2·12 "	5	9,890	
"	2·12 No. 11	5	10,100	

Unfortunately the English proof with which comparison is made is not the same as that which is now in force; still the experiments that were made with our old proof-charges are of interest since they show that the proof with small shot is more severe than with the spherical bullet of equal weight, and also that the difference may be considerable.

PROVISIONAL PROOF (16-bore gun).

The powder used corresponded very closely with R.F.G.[2].

Powder charge, F. S.	Shot.	No. of rounds.	Mean muzzle velocity.	Mean pressure in chamber.
Drams.			Ft.sec.	lb.
10·72	·9oz. No. 2 shot ...	3	2221	16,360
"	·9oz. spherical bullet	5	2152	14,100
DEFINITIVE PROOF (16-bore gun).				
6·77	·9oz. No. 2 shot ...	3	1916	12,120
"	·9oz. spherical bullet	5	1774	8,720

Experiments to ascertain the pressures given by service charges and proof charges used in England have been carried out by the *Field*, and a summary of results obtained in 12, 16, and 20-bores is given below, so that our readers may make a comparison for themselves between the English and French proofs. Under the existing Regulations of Proof in England, a "service charge" is specified for every bore, and the *compulsory* definitive proof is made with double the service charge of proof-house powder and 1⅛ the service charge of No. 6 shot. Besides the compulsory proof, a supplementary proof with other kinds of powder is permitted, if applied for. Many other charges, both larger and smaller than the officially stated "service charge," are in constant use. We give records of pressures of a dozen varieties of powder, with the most commonly used charge for 12-bores, as well as with the "service charge" laid down in the Proof-House Regulations.

ENGLISH 12-BORE GUNS.

Varieties of Powder.	A commonly used charge, 3drs. of powder and 1⅛oz. of shot.	"Service Charge," 3¼drs. of powder and 1⅛oz. of shot.	Definitive Proof Charge, 6¼drs. of powder and 1⅝oz. of No. 6 shot.
BLACK:	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.
Proof-House powder	2130	—	10,100
R.F.G.[2] (Martini-Henry).....	2420	—	10,450
No. 6 C. & H., T.S.	3860	4770	14,120
No. 4 C. & H., T.S.	5820	7790	16,150
" " Diamond	6990	—	—
" Pigou and Wilks	5820	—	—
" Hall and Son	5630	—	—
No. 3 C. & H., Diamond	7550	—	—
No. 2 C. & H., T.S.	6040	8690	16,400
" " Diamond.....	8960	—	—
NITRO POWDERS:	(42grs.)	(45grs.)	(90grs.)
Schultze	6110	6380	11,820
E.C.	5330	6830	16,100
S.S.	5980	8630	17,800

	English 16-bore Guns.		20-bore Guns.	
Varieties of Powder.	Service Charge, 2¾drs. powder and 1oz. shot.	Definitive Proof, 5½drs. powder and 1⅛oz. No. 6.	Service Charge, 2½drs. powder and ⅞oz. shot.	Definite Proof, 5drs. powder and 1oz. No. 6.
BLACK:	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.
Proof House Powder	—	10,570	—	12,920
No. 6 C. & H., T.S...	5790	—	5240	—
No. 4 " "	7480	—	8240	—
No. 2 " "	8780	—	8940	—
NITRO POWDERS:	(38grs.)		(34grs.)	
Schultze	8250	—	8220	—
E.C.	8960	—	9100	—
S.S.....	8510	—	9380	—

Commenting on the proof of sporting arms as carried out in France, the authors of the official report say that as sportsmen generally are either not aware of the differences that exist between quick and slow burning powders—or, at any rate, do not take these differences into consideration, and consequently may run a considerable risk when using heavy charges of certain powders—they therefore are of opinion that the proof of the finished arm should be so regulated as to cover this risk.

As an instance of the danger that there may be, they quote the fact that in a 16-bore gun the normal charge of a certain powder gives a pressure 12 per cent. in excess of that given by the charge used in the second or definitive proof.

They express their opinion that the proof as carried out in France is not as severe as it ought to be, particularly for the calibres smaller than 16, and that the definitive proof pressure should not be less than 14,000lb. per square inch. They allow, however, that the present proof is satisfactory from a practical point of view, because the actual bursting of a gun-barrel is but rarely heard of; yet, on the other hand, it is pointed out that if one examines a gun which has been much used, it will be generally found that it is more or less open at the joint between the barrels and the breech action; moreover, it is not a very uncommon thing to hear of a gun giving way at the action.

They think that a more severe proof would stimulate gunmakers to produce a stronger action, to the advantage of sportsmen who use it. And we are quite of opinion that this will hold good in England as well as in France. There is, however, the advantage in England, that anyone who wishes to do so can now have his gun tested with an explosive which is of greater strength than the ordinary proof-house powder.

The authors of the French report are strongly of opinion that the proof-houses should have proper appliances for measuring the pressures developed in the different arms, so that the proof-charges may be accurately regulated to the service conditions.

There are numerous causes which may give rise to a variation both of the maximum pressure and of the pressures along the bore of a gun. In the first place, the weight of the charge of shot will influence them; then, again, the pressure will not be the same if a bullet of the same weight as the shot charge is substituted for the latter.

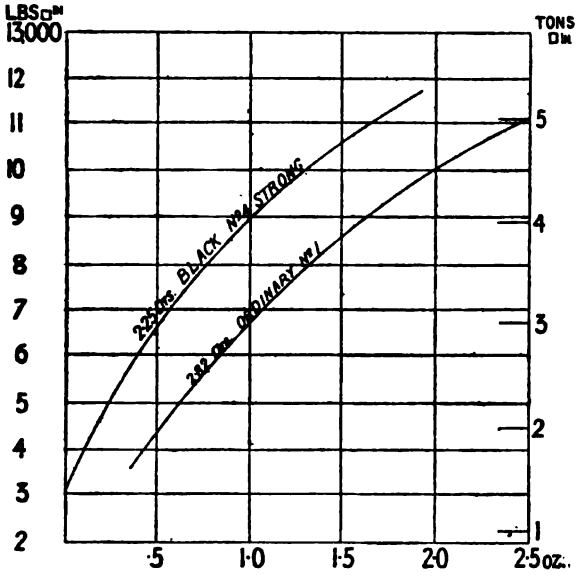


FIG. 6.—PRESSURES WITH BLACK POWDERS.

Fig. 6 shows the maximum chamber pressure in a 16-bore gun with two different descriptions of black powder, when the shot-charge is varied from something less than half an ounce to over 2ozs. These two pressure curves practically cover the whole range of the French black sporting powders, as will be seen from the table showing the various descriptions made and sold by the French Government. These are classified by the number of granules contained in the weight of one gramme.

BLACK POWDERS.

Quality of Powder.	Number of Granules to the Gramme.				
	No. 0.	No. 1.	No. 2.	No. 3.	No. 4.
Sporting powder, ordinary	800	2500	5000	10,000	—
Sporting powder, strong.....	,,	2500	5000	10,000	25,000

Besides these there are some special qualities, such as diamond grain and extra fine. The sizes of grain appear to have been based on those issued by English manufacturers, notably Messrs. Curtis and Harvey.

Of nitro powders only one description (the French) is given.

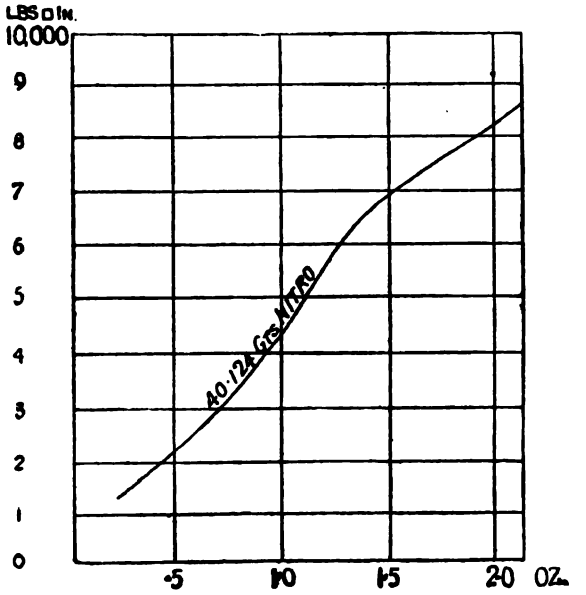


FIG. 14.—PRESSURE WITH NITRO POWDER.

Fig. 14 shows, in similar manner to the preceding figure, the variation of the chamber pressure with a charge of nitro powder where the weight of the shot is increased.

In Fig. 7 the curves of comparative pressures with three different projectiles of equal weights are clearly shown. The first one (a bullet of lead hardened with 5 per cent. of antimony, $\frac{8}{1000}$ths of an inch larger than the bore) gives a rather higher pressure than the

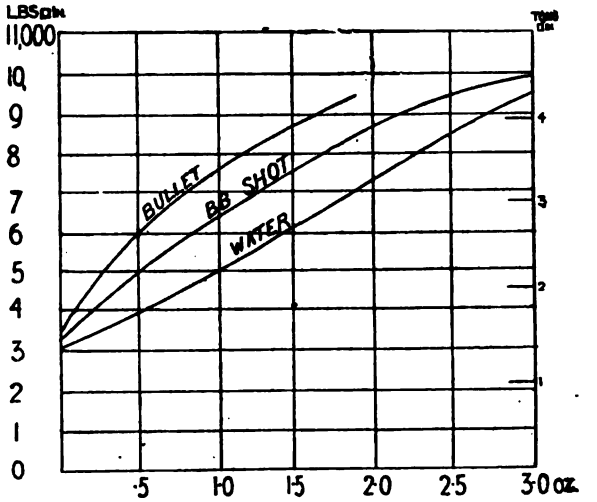


FIG. 7.—PRESSURES WITH PROJECTILES.

same weight of No. 2 French (= BB English) shot. The third one (viz., an equal weight of water being substituted for the shot) is somewhat lower than the other two—which may to a certain extent be accounted for by the fact that there was no wad over the water. In this case the gun was, of course, fired vertically.

It would appear as if the smaller sizes of shot give rise to rather higher pressures than the larger ones; but the difference is so slight that it was thought uncertain whether this really is the case or not.

The hardness of the shot does affect the pressure to an appreciable extent; the rise of pressure with chilled shot over that given by soft lead ones was about 15 per cent., though the velocity was only increased to the extent of 1 per cent.

The over-powder wad exercises a powerful influence, not only on the pressure in the chamber, but also on the regularity of the muzzle velocity. That found to be the best was a wad composed of a mixture of wax and grease, which, though perfectly plastic, was at the same time inelastic. The next best wad was found to be the felt one, $\frac{1}{10}$ths of an inch thick, saturated with grease, and placed between two cardboard wads. The saturation of the wad with grease increased the velocity over 100 f.s., and the regularity was also increased threefold, as compared with ungreased felt.

Temperature has but little effect in raising or lowering the pressure of black powders, though with nitro powders it causes very considerable and variable differences. Apparently, with the French nitro powder, the rise of pressure is about 11 per cent. for an increase of temperature of 10° F.; and practically the pressure given by a cartridge which has been exposed to the rays of a hot sun may be double that given in the same gun by another cartridge that has been subjected to a temperature below freezing.

The pressures along the bore of a gun, with different charges, natures of powder, and weights of projectile, form an interesting study of themselves; but the extent of this subject is so large that we can merely take a superficial glance at it, giving one or two typical diagrams to illustrate some of the more striking features.

If in addition to knowing the pressures in the chamber and the bore, we also know the time in which the maximum pressure is reached after the shot has started down the bore, and the total time that elapses before it leaves the gun, we shall be able to throw considerable light on the question of sensation of recoil as experienced when firing different natures of powder.

In the accompanying diagrams—which both refer to results obtained from a 16-bore gun—we see first of all, in Fig. 8, the difference between the pressures produced, at equal distances from the breech, with a charge of black powder and a charge of nitro in proper condition, the resulting muzzle velocity being the same with both powders; the lowest or dotted curve shows the pressures given be the same nitro charge after it has been exposed in a damp atmosphery and has taken up moisture.

In Fig. 9 we see the relations existing, under the same conditions, between the pressure and the time, counted from the first movement of the shot (at the left extremity of the diagram) to its departure from the muzzle.

On the principle that the service charge of any gun should not give more than three-fourths of the pressure obtained in the definitive proof (which we have seen was, in a 16-bore gun, 10,100lb. per square inch), a table is given below showing the charges of the various French powders that give, in a 16-bore gun, a pressure of 7570lb. per

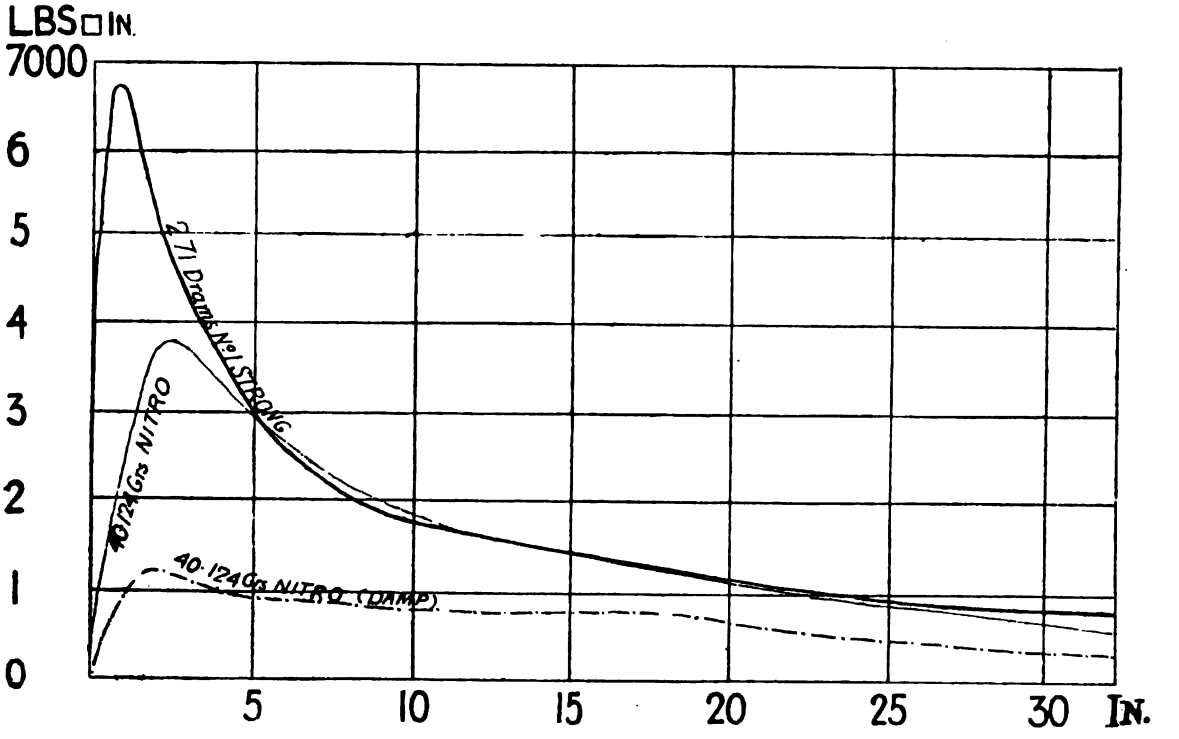


FIG. 8.—DIFFERENCES OF PRESSURE WITH BLACK AND NITRO POWDERS.

square inch, *i.e.*, three-fourths of that to which the gun is subjected a its definitive proof.

16-BORE GUN (1·06oz. shot).

	Charge.	Muzzle Velocity.
Rifle powder F 3 (similar to E.F.G.[3]).	4·46 drams	1525 ft.sec.
Sporting ordinary No. 0	3·95 ,,	1378 ,,
,, ,, No. 1	3·02 ,,	1214 ,,
,, ,, No. 2	2·71 ,,	1200 ,,
,, ,, No. 3	2·59 ,,	1101 ,,
Strong No. 1	3·04 ,,	1227 ,,
,, No. 2	2·57 ,,	1155 ,,
,, No. 3	1·83 ,,	1080 ,,
,, No. 4	1·80 ,,	1050 ,,
French nitro powder	42 grains	1398 ,,

From the above table (which is made out for a 16-bore, taken as a standard) the charges of the same powders that will give this same

pressure of 7570lb. per square inch, or the charges that will give three-fourths of the definitive proof pressure in other calibres, can be found by multiplying the 16-bore charge by one or other of the co-efficients for the other calibres, given below.

Number of Calibre.....	8	10	12	16	20	24	28	32
Co-efficient for pressure of 7570.b.	1·478	1·28	1·143	1	·889	·806	·735	·641
Co-efficient for three-fourths of proof pressure	2·15	1·68	1·32	1	·915	·695	·58	·497

(*Field*, Dec. 10, 1892; Vol. 80, p. 915.)

VII.—ON RECOIL.

It is not our intention to give our readers a mathematical discourse on the subject of recoil, but at the same time, in order to enable this subject to be clearly understood, it will be necessary to introduce one or two of the simple formulæ relative to the laws of motion and work, has not usually been taken into account in the formulæ given in our English text-books on military arms; and to its neglect may be attributed the disagreement that there has appeared to be between the theory of recoil, as thus expounded, and the practical results obtained.

Thus we see that, although when the shot charge leaves the bore it has very nearly attained its maximum velocity, the gun has not by any means done so, and that any calculation based *only* upon the velocity and weight of the shot must necessarily be faulty.

The work accumulated in a moving body is expressed by the formula:

$$E = \frac{wv^2}{2g}$$

where E = the accumulated work in foot-pounds;
w = weight of the moving body in pounds;
g = the acceleration due to gravity, taken as 32·2ft. per second;
v = velocity of the moving body in feet per second.

As by means of instruments it is possible to determine what the maximum value of v is, both in the case of the shot and of the gun, we are able, knowing also their weight, to ascertain from the above

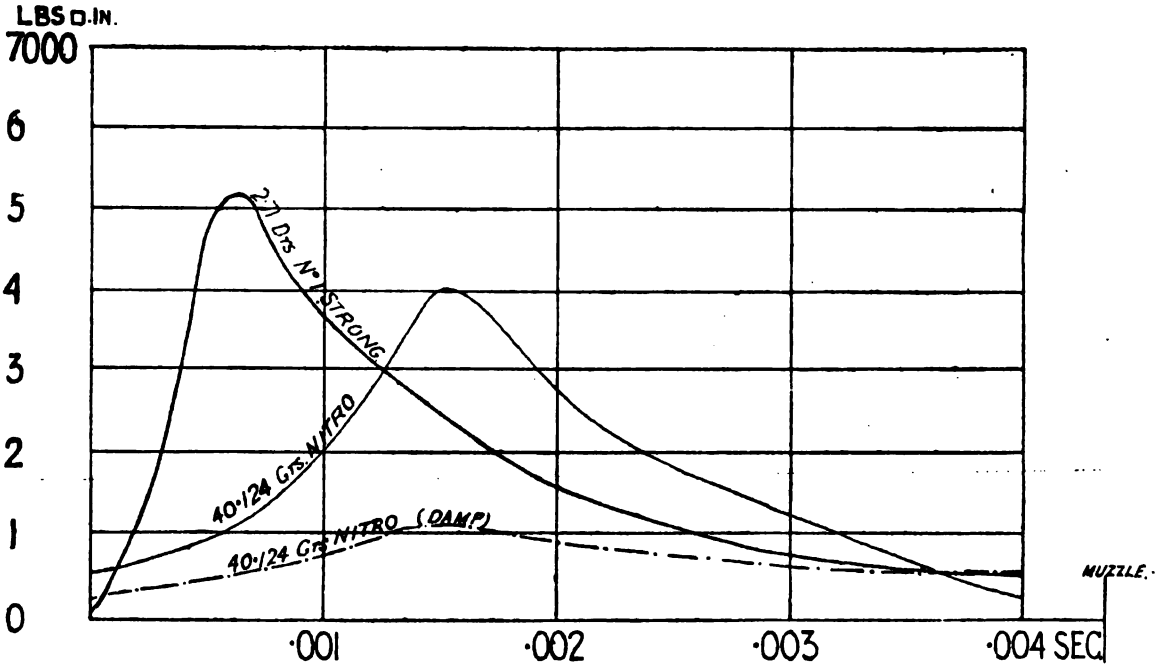


Fig. 9.—Relations between Pressure and Time

and also to explain how they can be applied to calculating the velocity and force of recoil.

It is a fundamental principle that action and re-action are equal and opposite; therefore, at the moment when the shot leaves the muzzle of the gun, the momentum (or weight × velocity) of the shot will be equal to the momentum of the gun. This is strictly true from the time the shot first commences to move until it finally leaves the muzzle, but only up to that instant. After that moment, owing to the velocity with which the shot is travelling as compared with the gun—generally not much less than a hundred times as fast—the powder (which has still a capacity for doing work until its pressure is reduced to that of the surrounding atmosphere) produces but a slight effect on the projectile; though the products of combustion continue to exercise an influence on the gun for a comparatively long time afterwards—until the powder gas in the bore is reduced to the same pressure as that of the atmosphere, as mentioned above.

This is a very important point in connection with recoil, and one which, as has been pointed out in our columns on previous occasions,* equation what is the amount of accumulated work in each of them; and we shall also find that the respective momentums of the shot and the gun are far from being equal.

To thoroughly investigate this subject of recoil, as affecting sporting arms, the French made a large number of experiments, using the Sébert velocimetre with some guns, and an improvised instrument of the same nature with others, such as 8, 16, and 32-bores.

Their conclusions are (1) that the physiological impression, or "kick," as it is usually termed in this country, is proportional to the work accumulated in the gun or to its "energy of recoil" as it is shortly called, and (2) that the same methods of calculation apply to small arms as well as to ordnance of the largest calibres, under their ordinary conditions of use. [Our own experiments (which have been carried out on very different lines from those of our French friends) have led us to the conclusion that, although the general effects of recoil are in accordance with the principles they lay down, the physiological impression, or "kick" on the shoulder, is due to the *initial* energy of the gun's movement—or perhaps it would be better to say the *greatest acceleration*—rather than to the total amount of work afterwards accumulated.—Ed.]

* Vide the *Field*, Sept. 20, Oct. 4, 11, and 18, 1890; Aug. 20, 1891, &c. (Here reprinted at pp. 122, Part I. and 177, 197, 205, &c., Part II.)

The formula given for obtaining the velocity of recoil (which is based upon the results of years of experiment with French ordnance) is as follows:

$$V = (1 + 1{\cdot}5c)\frac{v}{w}$$

where V = maximum velocity of recoil in feet per second
l = weight of shot and wads in pounds
c = charge of powder in pounds;
v = muzzle velocity of shot in feet per second;
w = total weight of the recoiling mass.

A table is subjoined which gives the energies of recoil, with details of weights of powder charges, shot charges, &c., for various sizes of guns, both with black powder and French nitro powder:

"forcement"* of the projectiles has any primary influence on the recoil.

Considerable differences in the "forcement" will, it is true, influence the combustion of the powder, and so affect the muzzle velocity and recoil. Variations in the bend of the stock may slightly vary the direction in which the recoil takes place, but can have no effect upon its intensity. The energy of recoil must be entirely absorbed in every case by the resistance opposed to it by the body of the sportsman.

One often hears that with nitro powder there is little or no recoil in comparison with that produced by black; as a matter of fact, as we have already seen, for the same muzzle velocity the recoil with black is about 20 per cent. more than with nitro powder.

BLACK POWDER.

	Weight of arm.	Weight of (A) Shot.	Weight of (B) Wads.	Weight of (C) Powder.	1.5 C + A + B.	Muzzle Velocity.	Velocity of Recoil.	Energy of Recoil.
	lb.	lb.	lb.	lb.	lb.	Ft. sec.	Ft. sec.	Ft. lb.
Rifle 1874 model.	9·39	·0551	·0013	·01157	·07375	1460	11·47	19·2
8-bore	13·0	·1322	·0077	·02072	·17098	1180	15·52	48·7
10	8·8	·102	·0066	·0165	·1333	,,	17·9	43·75
12	7·16	·0855	·0059	·0132	·1112	,,	18·35	37·5
16	6·72	·0661	·0055	·0106	·0875	,,	15·38	24·7
20	5·29	·0527	·0046	·0088	·0705	,,	15·72	20·4
24	4·85	·0443	·0042	·0075	·0597	,,	14·53	15·9
				FRENCH NITRO POWDER.				
8	13·0	as stated above with		·0110	·1564	1180	14·2	40·7
10	8·8	Black powder.		·0086	·1215	,,	16·3	36·3
12	7·16	,,	,,	·0070	·1 19	,,	16·8	31·4
16	6·72	,,	,,	·0056	·0800	,,	14·05	20·6
20	5·29	,,	,,	·0045	·0640	,,	14·3	16·8
24	4·85	,,	,,	·0038	·0542	,,	13·2	13·12

From the above table it will be seen that the energy of recoil of a 12-bore French gun (weighing about 7lb. 8oz., and loaded with about 3¾drs. powder and 1⅛oz. shot), is for the same muzzle velocity, with black and French nitro powder, 37·5 ft.lb. and 31·4 ft.lb. respectively. This means that, with the black powder, some 20 per cent. more work is required to be done to bring the gun to rest;* and as this work is done by the body of the shooter, it is pretty obvious that the recoil with black powder will be greater than with nitro.

The limit to the power of sporting arms must mainly be regulated by what an average man can stand in the way of recoil. But, in passing, it may be remarked that even this capacity varies at different times and under different conditions; for instance, recoil is much more felt when shooting at a target than when in the excitement of the moment of firing at game; again, if only a few shots have to be fired, a heavier recoil is admissible.

There are few men, it is considered, who can shoot well, for any length of time, with a gun whose recoil energy is greater than 44 ft.lb.

On no subject in connection with gunnery are there more erroneous ideas—superstitions one might almost call them—than on recoil. Many men will tell you that certain guns, with precisely the same ammunition, will give much more recoil than other guns of exactly the same weight. It will generally be found that these men are either novices in the art of shooting, or else they do not hold their guns properly up to the shoulder. Once and for all, it may be laid down that the recoil of guns, rifles, and arms of every description, from the smallest pistol to the heaviest piece of ordnance, proceeds from the same causes and depends upon the same elements.

Contrary to what has been laid down authoritatively in almost all treatises on firearms, neither the diameter of the chamber nor the

* Vide the *Field*, Aug. 29, 1891.

This assertion is based upon very accurate experiments carried out in three different calibres with two different descriptions of French nitro powders and two different descriptions of English nitro powders.

We have read in a pamphlet on sporting arms that a gun fired close to a wall gives more recoil than when fired in the middle of a field. The author of this statement evidently confused the shock to his nerves of hearing occasioned by the report with the shock to his shoulder produced by the recoil. One might just as well say that a cap fired in a room is stronger than when fired in the open air, because in the former case the report is louder.

(*Field*, Dec. 17, 1892; Vol. 80, p. 951.)

VIII.—THE DISPERSION OF THE SHOT CHARGE.

THE perfect shot (who, needless to say, exists only in theory) would shoot all sorts of game with a very accurate rifle of calibre suited to the description of game he was going to kill.

With a weapon equal in accuracy to the French army rifle of 1886, this ideal shot would seldom miss a partridge at 100 yards, or a hare at twice this distance, if they were correctly aimed at; and, therefore, strictly speaking, he would never miss them at all through any fault of his own. In reality, all gunners have considerable personal errors, which personal errors increase as the time, during which the game is visible, decreases, when this period is less than two seconds, and are still further augmented when the object aimed at is moving rapidly and irregularly away from them.

* This is a French word, for which we have no English equivalent unfortunately; it has, however, been Anglicised, and is now generally used in gunnery treatises. Its signification is the excess of diameter of the projectile over that of the bore.

To compensate for all these defects on the part of the shooter, a charge of shot which covers a considerable area in its effects is used instead of a single bullet.

Theoretically, it is obvious that the best weapon for an individual sportsman is that which will give such a spread to the pellets of the charge as will just cover a space or area equal to that covered by his own particular personal error; and again, since according to the laws of probabilities, this error may be either to the right or to the left, or high or low, therefore, the shot ought to be uniformly distributed all over the pattern, and not heaped up in the centre of it, as some gun-makers and sportsmen think, erroneously, that it should be.

Further on we shall see that the above conditions are very closely attained by the use of smooth-bore guns firing charges of shot.

With cylinder-bored guns, the actual spread of the shot covers about one degree of angle from the muzzle; this gives a pattern sufficiently close for a moderate shot, on ground affording a certain amount of cover. For certain game, however (such as snipe and rabbits for instance, which are very quick in their movements, as a rule only seen for an instant, and generally quite close), it would be better to use a gun giving more spread than the ordinary cylinder, and such a gun would probably be better for the tyro for all sorts of small game.

For wilder game, on the other hand, such as wild duck, geese, and bustard—and even for partridges where the country provides little cover, or the birds are very wild—it would be more advantageous to have a gun giving a closer pattern, and effective at a longer range than the ordinary gun is. Most sportsmen would have at one time or another made prodigious bags (at least so they will tell you), if they had only a gun which would have killed at 150 yards.

The Pattern.

If a charge of shot is fired from a smooth-bore gun at a vertical target of sufficient area to catch all the pellets, it will be found that a pattern of circular form is made, and the distribution of the shot within this pattern will follow the ordinary laws of probability. Although this may not be evident from the examination of the results of one round only, yet it will be quite clear that it is the case, if a number of diagrams obtained in a similar manner be superposed, and the mean taken.

Looked at from one side, a flight of small shot is densest in front, tailing off behind, and the individual pellets straggle more and more as the range increases.

Ocular evidence of this fact can be easily obtained by having a gun fired over a surface of smooth water, and placing one's self to one side of the line of fire, and at the same time above it, at a distance of about 60 yards from the muzzle, the gun being so aimed that the shot strike the water about this point. The most accurate method of ascertaining the spread of the pellets is to fire at a target of sufficient size to catch the whole charge, and then to measure the size of the rectangle or the length of the radius of the circle, that contains a certain percentage, from 50 to 100 per cent., of the imprints of the pellets. In order to reduce such measurements to a common standard, the probable mean distance of the pellets from the centre of the pattern should be ascertained from a table of probabilities, and from this the length of the radius of the circle containing from 50 per cent. of the hits can be derived.

For instance, firing a single round, one would measure the size of the rectangle containing the whole of the hits; then that of the rectangle containing the whole less 2, 5, 10, and 20 pellets respectively at the top, bottom, right and left. Then, knowing the dimensions of the rectangles containing a certain fraction of the whole number of pellets, one can, by means of probability tables, deduce the dimensions of the rectangle or the radius of the circle containing 50 per cent. of the pellets.

In order to catch all the pellets of the charge, the target must be made, for a range of 30ft., not less than 15in. square, and at 150ft. the target would have to be 9ft. square; so that practically it is most convenient to carry out such experiments at ranges of from 30ft. to 60ft., using targets of paper, which can be replaced after each shot.

In spite, however, of the greatest care taken in preparing the cartridges, &c., it will be found that the results from round to round will differ very considerably—as much as 25 per cent. from the mean; whilst the ratio of spread between the best and worst shots of a series may be in proportion of one to two.

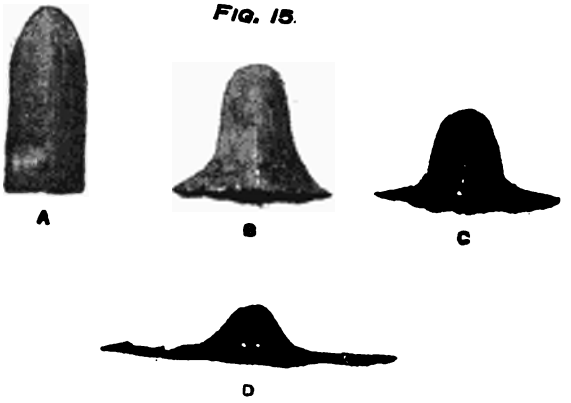
There are several causes which affect the dispersion of the charge of shot, but they may be broadly classed under two heads, viz.: Those affecting the spread (1) up to the time that the shot leave the muzzle, and as it leaves it, causing "initial dispersion"; (2) during their flight through the air, causing "subsequent dispersion."

On consideration it will be seen that if it were only "initial dispersion" that caused the shot to spread, then their deviation would be simply proportional to the range; but if, on the other hand, only the "subsequent dispersion" came into play, then the spread, *nil* the muzzle, would be very small at short ranges.

In reality, both these causes are at work in succession, and so he deviation of the pellets may be considered as the resultant of the variations due to the forces acting upon the shot charge in the bore, at the muzzle, and subsequently.

All the experiments connected with the dispersion of shot charges were made at a range of 33ft. (10 mètres). This distance, while

FIG. 15.

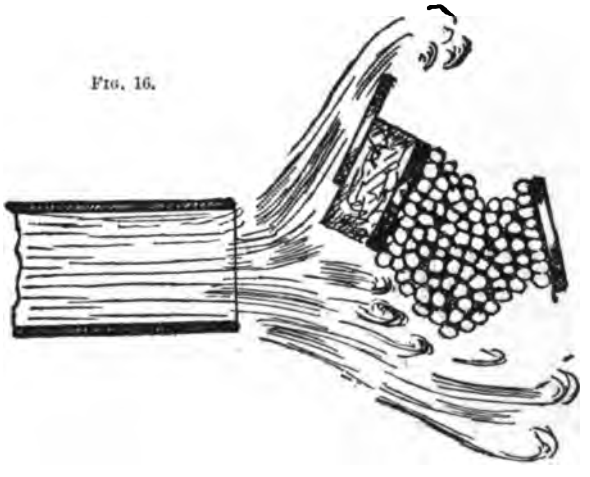


A, a bullet before firing;
B, after being fired with a moderate charge;
C, after being fired with a heavier charge;
D, after being fired with a very heavy charge.

sufficient to allow one to measure the dispersion, is not great enough for the variations produced outside the gun to have much effect.

If an elongated bullet, such as a rifle bullet, be fired from a very short barrel, so that it has only from one to five calibres travel, a curious phenomenon will be observed which has its analogies in sporting guns. It will be found that leaden bullets fired under the above conditions will have their bases more or less flattened, according to the pressure of the powder gases at the moment the bullets left the muzzle and to the softness of the metal of which they are made. It will be found that when the pressure on the base of the bullet exceeds a certain limit, the metal tends to crush

FIG. 16.



up. It is, however, so long as it is in the bore, supported by the barrel, but the moment it loses this support it is crushed out of shape.

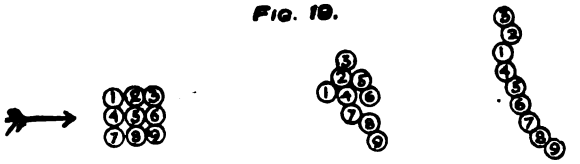
The four sketches in Fig. 15 show, about natural size.

Turning now to the shot charge, at the moment of its leaving the gun the forces acting upon it are as follows: On the one side there is the pressure of the powder gases tending to overcome the inertia of the mass of lead, and, on the other, there is the resistance of the air in front of the charge, acting in the opposite direction. The consequence of these actions is that the shot charge, which has no cohesive powers of its own, spreads itself out somewhat in the manner shown in Fig. 16, which represents the shot charge just after leaving the muzzle of a cylinder-bored gun. This explains why the rear and outside pellets fly off in the most divergent lines.

The following experiment, which anyone can carry out, supports this assertion:

A charge of shot is fired against a stout cardboard or soft wood target and the imprints examined. It will be found that the deformed

FIG. 16.

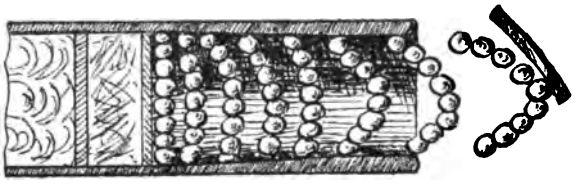


pellets, or those in rear of the charge, are on the outer part of the pattern in the proportion of two to one as compared with the spherical pellets; but in the central part of the pattern these proportions are reversed, there being two spherical pellets to one deformed one.

Now let us consider the movement of some pellets which leave the gun grouped closely together, and for the sake of simplicity let us take nine only. Fig. 19 represents the three successive positions of these pellets after leaving the muzzle of the gun. When they are grouped together, as in the first position, the resistance of the air will affect those in the front line, viz., 3, 6, and 9, almost entirely; on account of this, these pellets will roll over or rock on those in rear, assuming the second position; and subsequently they will resolve themselves into the third position, where they are shown all in line.

Then another cause of dispersion comes into play. Owing to the shape and movement of the pellets, the air is more or less compressed between them, and therefore tends to force them apart, until they attain such a distance from one another that the air-wave thrown off the surface of one pellet has no longer any influence on its neighbours. Thus it will be seen that the pellets originally projected in a

FIG. 17.



compact mass are forced to disperse, and to continue to separate from each other during flight.

In a chokebore gun the whole of the charge arrives at the choke in a compact mass, particularly the pellets in the rear of the charge, and in traversing the choke it meets with resistance which reduces its velocity for an instant. Eventually the near layers lose some of their velocity, which is transferred to the layers in front of them.* This action decreases from the front to the rear of the charge, the actual velocity of the pellets decreasing in the same ratio.

Fig. 17 gives a representation of what occurs in the choke of a gun, the distances between the pellets and the layers being purposely exaggerated, to show the action more clearly. (The layers are, in fact, only from four-thousandths to eight-thousandths of an inch apart at the muzzle, instead of being with the wide intervals shown in the illustration.) The same phenomena presented themselves to M. Tresca, a well-known scientist, when experimenting with forcing layers of various metals through a constricted aperture; but a common instance of this effect is seen in the jet from the nozzle of a fire-hose, where it is found that a similar choking or contraction of the nozzle produces a more compact stream of water. In this case the contraction can be greater, as, owing to a liquid being used, there is less resistance and friction than when a solid such as lead is employed.

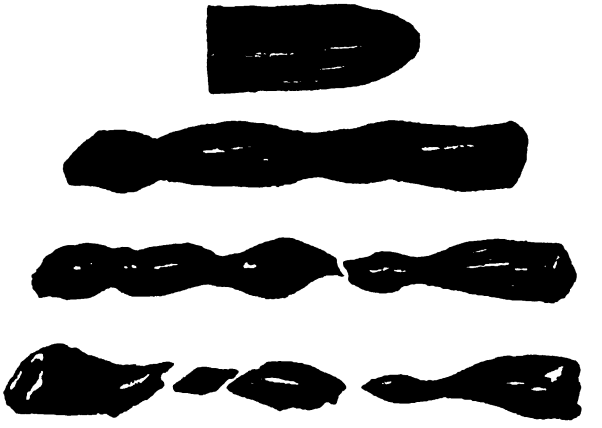
FIG. 18.

In comparing the chronographic results with similar cartridges fired from a cylinder and chokebore respectively, it is found that whereas, in the cylinder, the higher and more regular the velocities the less will be the spread, in the chokebore, since the velocity measured is that of the fastest pellet, the highest velocities obtained are in reality those from the rounds in which the differences between the velocity of the front pellets and those in the middle of the charge is exceptionally great. The regularity of the layers of shot must exercise a sensible influence on the dispersion. We may sum up the conclusions arrived at from these experiments as follows:

1. The greater the extent of the choke, the greater will be the difference of velocity between the front and rear pellets. If, however, the choke be excessive, the charge may jam, as shown (somewhat enlarged beyond full size) in Fig. 18.

2. The choke may vary from $\frac{1}{10}$ to $\frac{1}{3}$ of the calibre without much

FIG. 20.



altering the spread, but if the choke exceed this it may increase the spread instead of diminishing it.

3. The slope of the cone of the choked portion of the barrel may vary between considerable limits without affecting the result; but the gun is more strained by a steep slope than by a gentle one.

4. The cylindrical part of the bore beyond the choke should be

*This is an analogous phenomenon to that observed when a line of billiard balls at rest are struck by another ball at one end of the line, the motion being transferred through the line, and displacing the last ball at the opposite end.

longer in proportion as the slope is steeper and the choke more pronounced.

Some interesting results were obtained by firing an elongated bullet from a choked barrel of ·433 bore choked to ·310, with such variation of charges that the bullet reached the choked part at different velocities. Fig. 20 shows first of all the bullet leaving an ordinary cylindrical rifle barrel, and then the appearance of the same bullet after passing the choke, at velocities of 890, 980, and 1250 feet per second respectively. The appearance of the bullet thus fired is very similar to the *vena contracta* seen in a stream of water issuing under pressure from a narrow orifice.

Those who think of carrying out similar experiments are warned that they will certainly burst a good many barrels in the course of their experiments, no matter how thick or strong they are; and, if sporting guns be used, they will be bulged to a certainty, and probably burst.

(*Field*, Dec. 25, 1892 Vol. 80, p. 976.)

IX. DISPERSION OF THE SHOT CHARGE (*continued*).

If, instead of being smooth-bored, the barrel be rifled, the effect on the shot charge is, that the pellets on the exterior take the rifling, and, rubbing against the other pellets that are in contact with them, impart to them also a motion of rotation, which they in turn impart to others, and so on throughout the charge.

Thus the whole of the pellets of the charge leave the muzzle under the influence of a centrifugal force, which has a greater effect on the pellets individually, according as they are in a position close to the axis of the gun or not, and according to the quickness of the pitch of the rifling.

This centrifugal force necessarily increases the speed of the pellets after they leave the gun.

If fired at a vertical target, the exterior pellets around the charge will form an annular pattern, and likewise the rings of pellets between the exterior and the axis will also form annual patterns concentric with that formed by the exterior pellets; the pellets nearest the axis will strike in the centre of the pattern.

If the diameter of the pellets be large as compared with the calibre, distinctive patterns will be formed. With pellets whose diameter is one-third of the calibre there will be a central group, and annulus of pellets separated from each other by a considerable space, in which there are no hits; if the diameter of the pellets be one-fourth of the calibre, then they will form themselves into two rings of pellets. When the diameter of the shot, however, is less than one-fifth of the calibre, the distribution over the pattern will become practically uniform, more especially if the diameter of the bore of the gun divided by the diameter of the shot pellet is not a whole number; which is practically equivalent to saying that the shot charge does not lie evenly in layers.

From a rifled barrel the best results as regards uniformity of pattern will be obtained with a moderate charge of relatively slow-burning powder and hard shot of a diameter not exceeding one-fifth of the calibre. The interstices between the shot may be advantageously filled up with some material in the form of dust, as this plan prevents, to a certain extent, the deformations of the pellets under the pressure which is brought to bear on them by the powder gas.

A rifled shot gun may be of service when a great scattering effect is desired at close quarters, because, as was pointed out in the previous article, the sportsman stands a great chance of missing his game when the mean spread of his gun is less than the mean of his personal errors, which condition of things is more likely to be the case at short distances and game moving rapidly than at longer ones.

A gun, for instance, having its right barrel rifled with a twist of about one turn in 100 calibres, and the left barrel smooth, would be a very good weapon for shooting in a forest or thick covert.

The right barrel would give a pattern of double the diameter—that is, covering four times the area—of the left barrel or ordinary cylinder bore; and would therefore be very effective at short distances, and would also shoot a spherical or conical bullet with considerable accuracy; whereas the left barrel would be effective within the usual ranges of the ordinary shot gun.

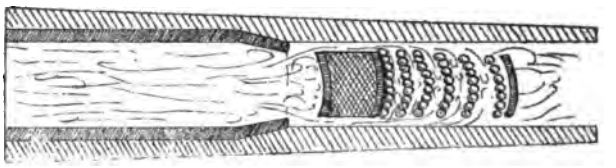
The best form of rifling for the above purpose would probably be the system known as Lancaster's oval bore, more particularly because there is less fear of "leading" with this description of boring than with the ordinary sections of rifling. The "leading," however, does not occur to a serious extent unless the velocity is higher than 1300 f.s., and even then has not much effect on the spread of the shot.

The Junction of the Chamber and the Bore.

The diameter of the chamber of all breechloaders is rather greater as a rule than that of the bore. Generally speaking the diameter of the bore is about equal to the interior diameter of the cartridge case, hence the diameter of the chamber and of the bore may be said to differ by twice the thickness of the cartridge case.

The chamber is connected with the bore by a portion of the barrel bored conical, the length of which portion varies from as little as one-tenth of an inch to as much as 3in., according to the gun. The best conditions, however, are attained when the length of the chamber is at least equal to the fired cartridge case.

FIG. 21.

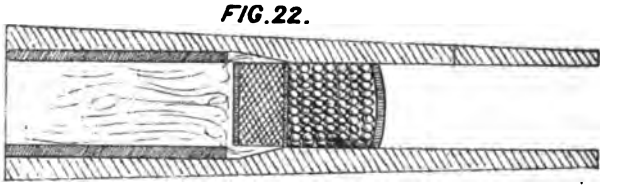


If the cartridge case be longer than the chamber, there is an escape of gas past the wad into the shot charge, which is thus separated in the bore, and the general result as to pattern and penetration is bad. A graphic representation of what occurs in the gun under such conditions is shown in Fig. 21.

This effect can be actually detected with black powder by looking through the barrel from the breech end after firing, when it will be noticed that the fouling is thicker for some 4in or 5in. from the end of the chamber, where the wad has not been in contact with the bore, after which the rest of the bore presents a normal appearance, since the wad has had time to expand and perform its proper function.

The fact of there being powder gas imprisoned in the shot charge will always tend to increase the spread of the pellets at the muzzle.

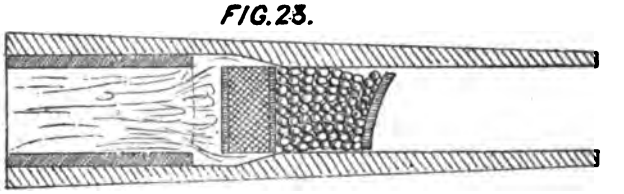
FIG. 22.



When the cartridge case is a little shorter than the chamber, and the wad thick and very plastic, the wad expands immediately on leaving the cartridge case, just like the cork of a champagne bottle when drawn and the gas is thereby entirely prevented from escaping past it. This condition of things is represented in Fig. 22, and is exactly what is to be desired.

If, on the other hand, the wad is not plastic at all, or if the cartridge case be much too short, it may allow a certain amount of powder gas to pass into the space there is between the forward end of

FIG. 23.



the cartridge case and the junction between the bore and the chamber. This is depicted in Fig. 23.

From the above point of view, and also because it is not always possible to get cartridges of exactly the right or even the same

length, the gentle slope is preferable to the steep one. The results, however, obtained from both systems are the same if suitable cases and thick plastic wads are used.

Some guns are made with the bore and chamber of the same diameter, and with shot charges these give, with plastic wads, quite as good results as chambered guns. They are, however, quite useless for firing bullets, which objection is not of great importance, as in many cases small game only is the question. Unchambered guns allow of cartridges of any length being used, and are therefore advantageous in this respect.

The condition of the bore does not seem to have much effect on the dispersion of the shot charge, as far as one can ascertain by firing guns whose bores are rough, rusty, and badly polished, in comparison with others whose bores are in good condition; but it stands to reason that a smooth, well-polished bore will give better results, even though the difference be slight and not readily discernible.

The length of bore does not, *per se*, affect the dispersion, and, for all practical purposes, may be considered not to affect the matter at all within the limits of length that the barrels of sporting guns are usually made, neither has the thickness of the barrel any influence upon it.

The exact size of the bore does not affect the spread either. This was proved by firing similar cartridges in two 16-bore guns, one of which was, however, four-hundredths of an inch larger in the bore than the other; no difference in spread could be detected. A similar experiment carried out in two 32-bores gave a like result.

One may therefore conclude that the slight differences in diameter of bore that exist between guns by different makers, &c., have no appreciable effect on their shooting.

The size of grain and the rate of burning of the powder does not affect the initial dispersion of the shot charge—a statement which is based on the observation of hundreds of rounds fired with all sorts of black and other powders.

The influence that the muzzle velocity has on the initial dispersion was ascertained by firing over 650 rounds from various guns, both cylinder and chokebore, and from 8 to 32 calibre, using both black and nitro powder, increasing the muzzle velocities by 50 mètres (164ft.) at a time. The results may be summarised as follows:

With black powders the muzzle velocity may vary from about 650 f.s. to 1650 f.s., without having any marked effect on the dispersion—at any rate, so far as 8, 10, 12, and 16 bores are concerned; with a very small bore, 32 gauges, the dispersion was rather greater at high velocities than at low ones.

With the French nitro powder (old type) the dispersion was practically the same, so long as the muzzle velocity exceeded 820 f.s.; below this velocity the charges burnt very badly, and the muzzle velocities were consequently irregular.

There does not appear to be much to choose between the dispersion caused by nitro and black powders, for, from a large number of rounds fired in 12 and 16-bore guns, both cylinder and chokebore, the nitro-powder gave a little more dispersion than the black, but in the larger calibres, 8 and 10, the reverse of this was found to be the case.

At a distance of about ten yards the dispersion with a good chokebore will be only two-thirds that of a cylinder gun.

The general results of firing a large number of rounds with varying weights of shot in different calibres tended to show that practically the dispersion could not be considered as a function of the weight of the shot charge.

On the other hand, the size of the pellets themselves has a very marked effect, the smaller the pellets the greater being the spread.

(*Field*, Dec. 31, 1892; Vol. 80, p. 993.)

X.—DISPERSION OF THE SHOT CHARGE (*continued*).

THE "Initial Dispersion" (as defined in Art. VIII.), is the same whether soft lead or hard chilled shot be used.

An interesting experiment to ascertain the effect of firing pellets of cylindrical as opposed to spherical form, was carried out in a 16-bore. The charge of shot was replaced by a somewhat less weight than the normal, viz., ·89oz. of copper cylinders, each ·118in. in diameter, and ·118in. in length; these cylinders were arranged in six regular layers of fourteen each, making a total of 84. Several rounds loaded in this manner were fired, and it was found that the spread at 38ft. range was considerably greater than the ordinary spherical lead shot fired from the same gun.

WIRE CARTRIDGES.—Some of these cartridges, obtained from a French ammunition company, were also subjected to trial. They were constructed as follows: The iron wire network to contain the shot had a mesh of ·157in., and was closed at one end, and quite open at the other; round the outside of the network some strong paper was wrapped. The charge of shot was then poured into the receptacle so formed, and the interstices filled up with bone dust; a thin felt wad was placed top and bottom.

In loading wire cartridges, care should be taken to load them with the open end uppermost, as the result of firing them with closed end foremost is that they almost invariably ball. There can be no doubt that wire cartridges do give slightly less spread from a cylinder gun than the ordinary shot charge loaded in bulk, but the reverse is the case if they are fired from a choke-bore.

The manner in which the wire netting acts in a cylinder gun is by preventing the spreading out of the rear portion of the shot charge just after it has left the muzzle of the gun.

A wire cartridge has yet to be devised, however, that can be depended upon to act regularly and with certainty.

Some persons think that there is an advantage to be gained by using some substance to agglomerate the pellets of shot after they have been loaded in the cartridge. Such substances as resin, sulphur, wax, and grease have been recommended, and were accordingly experimented with; but in all instances the results were poor.

The reason for this is not far to seek. If the substance used to agglomerate the shot is plastic and not brittle, there will be a tendency for the charge to ball; if, on the other hand, it is brittle, the charge will be broken up in the bore, but portions will, nevertheless, adhere to the individual pellets, not only reducing their velocity by impeding their flight through the air, but also greatly increasing their speed on account of their irregularity of shape.

There appears to be some slight advantage to be gained by using some substance in the form of dust, such as flour, talc, &c., which is but slightly compressible, to fill up the interstices between the pellets, and thus prevent them from losing their spherical shape; but the advantage obtained is probably outweighed by the disadvantage of increased smoke and increased weight of charge, which diminishes the muzzle velocity.

In a former article it was stated that a paper cartridge which split longitudinally in the body always gave rise to a considerable decrease in muzzle velocity, sometimes as much as 160 f.s. The reason of this is as follows: The split in the case leaves a deep and narrow groove, into which the wad cannot expand, and through which consequently the powder gas finds its way into the shot charge, thus causing not only a loss in muzzle velocity, but also increasing the spread at 38ft. range as much as 50 per cent.

As some sportsmen believe in "sectioned" cartridges, that is, cartridges which have been nearly or entirely cut through in a circumferential direction behind the shot charge, it was deemed advisable to try some experiments with such cartridges, cut both in front of and behind the wads in rear of the shot.

The first experiments were made with the cases cut through behind the wads. Under such conditions, if the case is not broken up during its passage down the bore, the charge goes like a bullet; and if the gun be aimed over hard ground, a little short of the mark, the case will probably break up and release the shot, which then disperse, like the bullets from a Shrapnel shell burst by a percussion fuze, and make a very close pattern on the object if near to the point where the first impact occurs. In this manner the experimenters were able to make patterns in which the whole of the pellets were contained in a circle whose diameter was only an inch or so, at ranges of from 55 to 110 yards. They mention this as a curious fact only, but do not recommend the method as suitable for actual use. The path through the air of such a projectile was found to be very irregular when fired from a smoothbore, and it was consequently not easy to hit the ground or the object exactly where it was intended.

Firing such cartridges from a rifled barrel gets over this latter difficulty, but then the centrifugal force bursts the case if not made of stronger material than paper. If the cartridge case be cut through just behind the shot, what generally happens is that the larger portion of the shot charge leaves the case just after they both leave the muzzle, and the shot charge then spreads as usual, but occasionally an extraordinarily close pattern is made at a long range. The results are essentially very irregular, and the only case in which one would employ such a method would be when, on account of the range, it would be useless to fire the ordinary charge of shot, and no other expedient was available.

CONCENTRATORS.—Instead of the somewhat primitive and objectionable plan of cutting through the cartridge case as above described, devices known as concentrators may be used. These consist of small tubes of cardboard, about half an inch long, which fit tightly into the cartridge case where the shot rests; in the experiments that were made two such concentrators were used in each cartridge, and were found to be effective in reducing the dispersion with a cylinder gun, but not with a chokebore.

They act in the same manner as the wire net in the wire cartridge,

viz., by reducing the speed of the rear pellets when the charge leaves the muzzle.

In considering the question of the "initial dispersion" generally, the importance of having a suitable over-powder wad cannot be overstated. Should this wad obturate insufficiently, the shooting will be bad from both cylinder and chokebore gun, but more especially from the former.

It should be greased so as to clean the bore after it, and thus prevent the fouling accumulating; the drier the air and the "dirtier" the powder, the more important is the function of the wad in this respect.

The "subsequent dispersion" (*vide* Article viii.) was found to vary with the range, when tested with the same gun and size of shot, but the spread of the shot increased as the size of the pellet decreased.

The subjoined table shows to what extent this occurs in a chokebore and cylinder gun respectively up to ranges of 87 yards, with large and small shot:—

CHOKEBORE.

Range. Yards.	BB. Shot. Diameter of circle containing 75 per cent. of pellets.	BB. Shot. Diameter of circle containing 98 per cent. of pellets.	No. 9. Shot. Diameter of circle containing 75 per cent. of pellets.	No. 9. Shot. Diameter of circle containing 98 per cent. of pellets.
	Ft.	Ft.	Ft.	Ft.
11	·5	·85	·65	1·0
22	1·2	2·1	1·7	2·9
33	2·2	3·6	3·3	5·9
44	3·2	5·4	2·9	10·2
55	4·6	7·5	9·2	16·0
65	6·4	10·5	13·4	22·6
76	8·5	14·1	17·7	29·8
87	11·3	19·0	21·9	38·4
	CYLINDER.			
11	·9	·9	·9	1·5
22	1·9	3·2	2·2	3·6
33	3·1	5·3	4·2	7·2
44	4·4	7·3	7·2	12·1
55	5·9	9·8	10·8	18·0
65	7·5	12·8	15·1	25·2
76	9·8	16·4	19·0	32·1
87	12·4	20·9	23·6	39·3

It will be seen from the above that the spread increases more rapidly with the small shot than with the large.

The increase of spread is less for chilled shot than for those made from soft lead, owing to the former keeping its shape better; at 50 yards the spread of a chilled shot charge was found to be only 83 per cent. of a similar soft lead one.

In general it may be said that any means taken to prevent the deformation of the pellets, whether by using slower powder, harder lead, concentrators of paper, which prevent the shot from touching the bore of the gun, &c., will tend to increase the efficiency of the shot charge, both as regards its striking velocity and also as regards the closeness of the pattern at any given range. To this end, too, should the choking of a gun be regulated; if excessive, such as $\frac{1}{4}$ of the calibre, the result will be that, although the pattern at a short distance will be closer than that of a moderate choke, such as $\frac{1}{20}$ of the calibre; at a longer range, 40 yards, for instance, the pattern will not be so good as that made by the latter.

(*Field*, Jan. 7, 1893; Vol. 81, p. 3.)

XI.—SIGHTING AND AIMING OF GUNS.

Most sportsmen are probably aware that, owing to the metal of the barrels being thicker at the breech end than at the muzzle, and to the rib which connects them being taper, their axes are not parallel, but, if prolonged, would meet at some distant point in front of the muzzle. The angle that the two axes make with one another is called the "angle of convergence," and is generally from 20min. to 25min.; it is, of course, in the horizontal plane. In a similar manner the line of sight* and the axis of the bore† prolonged make an angle in the vertical plane.

Since the line of sight is nearly parallel with the upper surface of the barrel, it consequently does not make the same angle with the axis of the bore in different calibres of guns, and the angle may vary from 50min. with a 16-bore to less than 20min. with a 12-bore.

From a shooting point of view, as will be seen further on, the best conditions are attained when the gun carries about 1in. above the point aimed at, at 33ft range.

In carrying out a number of experiments with different charges of powder, it was found that the centre of the pattern was always in the same spot, so long as cartridges accurately and identically loaded were used; but that the position of this spot would vary with the charge, or, to speak more exactly, with the muzzle velocity.

A phenomenon, curious at first sight, will be observed, viz., that if the charge be increased beyond a certain extent the gun will carry lower and lower as regards the point aimed at.*

This was found to be the case with all the guns tried, a considerable number, and a Spencer repeating shot gun was no exception to this rule.

In remarking upon the "regulation" of guns generally, the author states that he has usually found 16-bore choked guns so badly regulated that if the charge be only a very little heavier than usual, and the gun be accurately laid on a mark, the whole of the pellets will strike below the point aimed at.

A common mistake, made equally by sportsmen and gunmakers when trying their guns, is to use too small a target and too long a range; the small target has the defect of not showing the position of all the pellets, which is likely to lead to an erroneous conclusion, for it is clear that if one fires a gun that is very badly "regulated" for a heavy charge at such a small target only a portion of the pattern will be registered thereon, from which one might conclude that the charge was scattering the shot to a great extent, whereas in reality the centre of the pattern was not on the centre of the target.

That the vibration which is set up in a firearm when discharged has some effect on its regulation, the following considerations will show.

All hand guns have their centre of gravity a certain distance below the barrel or barrels; the result of this is that when the gun is fired it turns about this point. The muzzle rises, and the stock tends to go down. This occurs if the butt of the gun is not resting against anything; if the butt be supported by the shoulder, the turning movement will take place about the point of support. On account, however, of the elasticity of the shoulder, the result, as far as turning movement is concerned, is practically the same as if the gun were not thus supported, since the gun has moved such a short distance in recoil before the shot has left the muzzle; any subsequent movement of the gun can have no effect on the direction of the shot. Hence it is that the force with which a gun is pressed to the shoulder does not appreciably affect the accuracy of the shooting.

In single-barelled guns, since the centre of gravity is situated vertically below the axis of the barrel, the turning movement only takes place in the vertical plane; but in double-barrelled guns, where the barrels are placed side by side, there is a turning movement in the horizontal plane as well, when only one barrel is fired. This produces a compound movement as the resultant of these two forces.

The turning movement takes place with extreme rapidity, and causes different parts of the gun to undergo considerable flexion; the elasticity of these parts, however, enables them not only to spring back to their original positions before firing, but to actually go beyond them, thus setting up a true vibration, which, commencing as it does with the recoil, continues for some hundredths of a second after the projectile has left the gun.

The initial flexion due to this turning movement and the vibrations that follow it increase in amplitude, for the same gun, in proportion to the velocity of recoil. In breechloaders, the joint at the false breech, which yields more or less to the pressure of the gas, must evidently have some influence on the above movement; but in a well-constructed gun the yielding will be slight and the vibrations exceedingly rapid in comparison with those caused to the barrel as a whole and due to the recoil.

It was found that with a single barrel, symmetrically bored and fitted with a rigid breech mechanism, and not mounted on a stock, the vibration when fired was almost inappreciable.

The expansion of the bore caused by the pressure of the powder gas gives rise to what might be called "diametrical vibrations;" but these are very minute, and can have no effect on the shooting of the arm.

By means of special apparatus the actual vibratory movements of the various parts of a gun which occur on firing were registered, and from these it was ascertained that all sporting guns, as far as their

* The line of sight is a straight line passing from the eye through the sights to the object.

† The axis of the bore is a straight line passing down the centre of it.

* A similar result was found in some experiments alluded to in the *Field* of July 30, 1892. The effect was there traced to the "springing," or bending of the "hand" of the stock.—Ed.

vibrations in the vertical plane are concerned, behave in a similar manner.

The diagrams show (in a purposely very exaggerated manner) what occurs on firing. Fig. 24 represents the gun before firing; Fig. 25 shows the position it has taken up at the end of the first simple vibration, when it will be noticed that the muzzle is bent downwards

FIG. 24

FIG. 25

FIG. 26

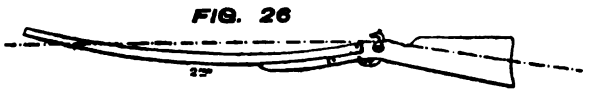
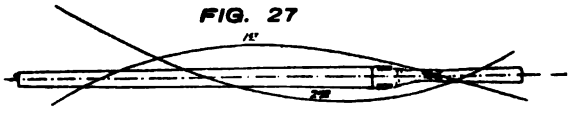


FIG. 27



from its original position; it then passes through its original position again, and assumes that shown in Fig. 26 at the end of the second simple vibration. It will be noticed that one nodal point of the vibration is about 12in. from the muzzle, and it will naturally be asked, cannot it be so arranged that the nodal point shall occur at the muzzle. Unfortunately, this is not possible in practice.

The vibratory movement in the horizontal plane produced by firing the right or left barrel of a double-barrelled gun was also studied, and found to have the same general character as the vertical vibratory movement; the period of a complete vibration was found to be about ·01sec., and to vary but little with the calibre of the arm itself. This movement is represented in Fig. 27, the right barrel having been fired.*

The position of the muzzle when the shot leaves it is of importance; it was ascertained by experiment that it was generally at the completion of the first simple vibration of the barrel (as in Fig. 24) when the shot left.

The amplitude of the vibration and consequent bending of the gun increases, as we have already said, with the muzzle velocity and the recoil, which explains the fact of a gun carrying low with a heavy charge.

The above remarks, naturally, only apply strictly to guns of the same proportions as those in general use, the time also during which the shot is travelling down the bore will modify these actions somewhat. This subject has a wide field, and is one that has not, as far as we know, been studied with any precision in England as yet, though in France much attention has been given to it, especially in connection with the service rifles.

Reverting to the question of the defects noticed in the "regulation" of guns, and particularly the 16-bore, the experimenters suggest two methods of surmounting the difficulty; the first is to raise the rib at the breech end by means of a piece of metal similar in section to the rib, and about 1in. long, attached to it by a single screw. This is recommended as not entailing any alteration to the barrels themselves, and as not interfering in any way with the practical sighting by the sportsman. It is stated that several gunmakers in France have adopted this method with satisfactory results. The second method is to bend the barrels to a gentle curve in an upward direction; this was found to be possible, without affecting the pattern in the slightest degree, in the case of several guns which shot much too low; but it is advisable to employ only a skilled gunmaker to perform such an operation, the bending being effected by means of a vice and suitably curved hard wood blocks.

* See p. 90, Part 1.

(*Field*, Jan. 21, 1893; Vol. 81, p. 73.)

XII.—THE THEORY OF AIMING.

In the previous article the importance of having a gun properly regulated was dwelt upon at some length, since it would be clearly impossible to take into account a correction of this description when firing at game; the sportsman could hardly be expected to remember, for instance, that his gun always shot 12 inches to the left of the object aimed at, at 40 yards range, and so on.

At the same time, however, he should be fully aware that, even with the best regulated gun, aiming at the centre of the mark does not by any means ensure that the shot will strike that point under all circumstances.

Thus in the case of an object in motion much will depend upon the speed of the object itself, whether it is approaching or not, whether there is a strong wind, &c.

Before we can study this question in its theoretical aspect so as to be able to apply a correction in aiming to allow for the object being in motion, we must first of all know the time of flight of the different sizes of shot for various ranges.

In the subjoined table is shown the time taken by two sizes of shot to travel the same distances, from 11 to over 100 yards.

Muzzle Velocity, BB shot, 1191 f.s.
" " No. 9 shot, 1181 f.s.

Range.			Time of flight in seconds.		
Ft.		Yds.	BB shot.		No. 9 shot.
33	.....	11	·030	.....	·033
66	.....	22	·065	.....	·075
98	.....	32	·103	.....	·127
131	.....	43	·146	.....	·192
164	.....	54	·195	.....	·270
197	.....	65	·252	.....	·363
230	.....	76	·317	.....	·472
262	.....	87	·391	.....	·606
295	.....	98	·476	.....	·772
328	.....	109	·574	.....	·974
360	.....	120	·686		
393	.....	131	·818		
426	.....	142	·976		
459	.....	153	1·165		
492	.....	164	1·390		

The correction to be made when aiming and firing at an object in motion depends both upon the speed of the object in the plane of sight and also upon the manner in which the correction is made.

For the same range this correction will obviously be proportional to the speed of the object.

In one case only, viz., when the object is moving along the line of fire, is no correction necessary; from this direction, however, the correction for a given velocity at a given range gradually increases until it attains a maximum on the line perpendicular to the line of fire.

In the following calculations it is this maximum only that will be taken into account.

Theoretically* there are two general methods of treating the question of firing at a moving object. The first method is to consider the gun aimed at a point in advance of the object, and fired when the object comes in line with it; the second method is to aim at the object itself from the first, but to give the gun an angular movement so as to follow the object and fire at it thus. We will now consider, employing both these methods, what distance there will be between the centre of the pattern and the point aimed at in either case. Imagine that at the moment when the gunner fires, the gun is pointed exactly at the object, which is moving at a velocity V feet per second, and that the shot takes s seconds to reach the point aimed at, then the distance between the centre of the object and the centre of the actual pattern will be equal to Vs.

This time s is composed of:

(1) That which elapses between the gunner determining to fire and the movement of his finger actuating the trigger; this may be taken as from ·1 to ·3sec.

* Practically neither of the above methods alone is followed, but what actually occurs is this: The sportsman brings his gun to his shoulder very nearly in line with the bird or other moving object, as soon as he is truly in line he gives the gun an angular movement so as to bring his gun on to the point desired, and fires when this is attained. Even then it is very unlikely that the angular movement of the gun and object is identical, and, in fact, the best shots will tell you that it is very seldom that the gun is directed exactly on the right spot.

(2) The trigger has to be moved a short distance at a comparatively slow speed before it releases the hammer.

(3) The hammer takes from ·01sec. to ·1sec. to strike the cap, according to the strength of the mainspring and the weight of the hammer.

(4) Then some three to six thousandths of a second elapse between the cap being struck and the shot leaving the gun.

The time taken by the whole of the above actions seldom amounts to less than ·2sec.

The distance then, between the centre of the pattern and the point on which the gun is directed when the shot is fired, is in general terms, calling t the time of flight of the shot, equal to V (t + ·2).

The subjoined table gives these distances at various ranges for an object moving perpendicularly across the line of fire at a velocity of 49·2 feet per second, which is approximately that of a partridge or a hare, when disturbed and making their escape. The gun is supposed to be aimed and fired according to the first method above described.

OBJECT MOVING AT 49·2 PER SECOND.

1ST METHOD.

Range in feet.	Distances between centre of object and centre of pattern.		Radius of circle containing 98 per cent. of the pellets. (Cylinder gun.)	
	BB shot.	No. 9 Shot.	BB. Shot.	No. 9 Shot.
	ft.	ft.	ft.	ft.
32·8	11·3	11·5	·75	·78
65·6	13·0	13·5	1·64	1·9
98·4	14·9	16·0	2·65	3·6
131·2	17·0	19·3	3·67	6·2
164	19·4	23·1	4·92	8·8
196·8	22·2	27·7	6·52	12·4
229·6	29·0	39·6	10·49	19·6
262·4	38·0	57·7	—	—

On examining this table it will be seen that the correction that should be applied at the ordinary ranges of thirty or forty yards is about 16ft., that being approximately the distance between the centre of the pattern and that of the object; and it is evident from this that the object will invariably be missed if fired at by the first method, that is, when the centre of the object crosses the line of sight.

Applying now the second method to the same case; here the time which elapses before the shot reaches the muzzle has not to be taken into account, since the gun is following the object, and therefore the shot in this case starts from the muzzle of the gun along the line of sight, which at the moment is aligned with the object.

The distance thus becomes, in this case, equal to Vt.

Since for the shot to be effective the object must be as a rule, within the circle containing 75 per cent. of the shot pellets, the subjoined table is made out under this assumption, and therefore shows the minimum correction that must be applied in order that the object may be within this circle.

OBJECT MOVING AT 49·2 FEET PER SECOND.

SECOND METHOD.

Range.	Distance.		Radius of Circle containing 75 per cent. of shot chokebore gun.		Minimum correction that must be applied to hit object.	
	BB.	No. 9.	BB.	No. 9.	BB.	No. 9.
	ft.	ft.	ft.	ft.	ft.	ft
32·8	1·47	1·64	·262	·328	1·21	1·81
65·6	3·18	3·6	·656	·88	2·5	2·98
98·4	5·08	6·23	1·08	1·8	3·9	4·95
131·2	7·18	9·4	1·64	3·28	5·5	6·23
164	9·58	13·1	2·29	4·9	7·2	8·2
196·8	12·4	17·8	3·18	6·8	9·1	10·8
229·6	19·2	29·8	5·57	10·8	13·4	19·0
262·4	28·2	47·9	—	—	—	—

By this method the correction to be applied for ordinary ranges of 30 to 40 yards is reduced to about 5 feet, and under these conditions also every shot fired would miss the mark.

A sporting gun of the ordinary description should be "regulated" exactly for a range of about 40 yards. At less ranges such a gun will carry higher, and at greater distances lower, than the mark and at 11 yards range would carry about one inch above the mark. Such being the case no correction for the object being close or distant, is absolutely necessary in aiming within the ordinary ranges at which the game can be expected to be killed. A duck gun carrying heavier charges of powder and shot would be "regulated" for a longer range —60 to 70 yards or more.

There is another cause of deviation that must be taken into account, namely, the force and direction of the wind. The table gives the maximum deviation due to a wind across the range which is the only case that need be taken into account.

BB SHOT

Range.	Deviation.		Radius of circle containing 75 per cent. of the pellets.
	Moderate wind. Velocity 13ft. per second.	Strong wind. Velocity 33ft. per second.	
ft.	ft.	ft.	
65·6	·13	·32	·65
98·4	·39	·48	1·08
131·2	·78	1·9	1·6
164·0	1·3	3·2	2·2
196·8	2·2	5·5	3·1
229·6	3·2	8·2	5·5
262·4	4·3	10·8	—

A correction for wind is only necessary, therefore, at ordinary ranges when the velocity is greater than 16ft. per second in the direction perpendicular to the line of fire; the deviation caused by a strong wind is greater than the radius of the 75 per cent. circle at all distances of over 35 yards, and therefore a miss would be the certain result of even a sitting shot at those distances, if the gun were aimed directly on the mark.

There are certain traditions which are prevalent among sportsmen. One of these is that the range of a gun is less when it is fired over water or across a deep valley, which they attribute to an attraction produced by a vacuum; such ideas do not rest on any scientific basis, and have probably arisen from the fact that it is more difficult to judge the actual range under such conditions than on ordinary ground.

The attraction produced by the earth is practically the same at the bottom of a mine and at the greatest heights than man can reach. On high mountains, it is true, a bullet will range further than on the plains below, but this is due to the rarefaction of the air at great heights, but the increase of range due to this cause with a shot charge is infinitesimal.

The personal errors of the sportsmen themselves vary very considerably, according to their expertness and the condition of their nerves. The presence of a dangerous animal, or even the sudden appearance of a harmless one, will often excite the nerves and agitate the sportsman; and every experienced shot knows that his personal error is largely increased under such conditions.

Take, for instance, the infantry soldier, who, though a first-class shot in times of peace, will make a clean miss, at a few yards only, of a cavalry soldier riding down upon him—rather a large mark in comparison with a piece of game. Again, how often do men miss one another with a revolver at quite a short range.

It is impossible to say what the personal error is under such circumstances with any semblance of exactitude.

We are not aware that any special experiments with shot guns have ever been carried out with a view to ascertain exactly what the personal errors are, as a rule; but a very great many trials have been made with army rifles. These show what the personal error is likely to amount to when an animal gets up, and is comparatively deliberately aimed and fired at.

Firing under such conditions with a rifle (about 1·8sec. being allowed for raising the gun to the shoulder, aiming, and firing), it was found that at 100 yards the personal error was from 11in. to 27in., the lower limit being that due to an exceptionally good shot.

There is another method, however, of measuring the personal error of the gunner.

We may take it for granted that with a charge of shot of suitable size, small game can be killed almost with certainty at 30 yards if the gun be held straight on them: but they will also be killed if they are within the circle containing 75 per cent. of the pellets. Therefore everything missed at 30 yards is missed by reason of the personal error of the gunner being greater than the radius of the above circle, which is about 18in. at the above range.

Reasoning from the above we may divide sportsmen according to their capabilities into two classes:

(1) The moderate shot, who at 30 yards misses a fair chance every other shot; and

(2) The excellent shot who rarely, if ever, misses a fair chance at 30 yards.

These two categories correspond closely with the limits of personal error which we have given above, viz., 27in. and 11in. respectively at 100 yards.

The very best practice for a game shot is to fire at a moving or "eclipse" target with full charges of powder and shot in his gun at about 30 yards range—the target being large enough to enable it to be hit every time, otherwise the lesson that might be learnt is often lost. Most sportsmen will be greatly astonished when they try this experiment to find how very far from perfect their shooting really is.

(*Field*, Feb. 4, 1893; Vol. 81, p. 143.)

XIII.—THE SHOT GUN AND ITS POWERS.

The power of a shot gun depends on a good many different elements, which are more or less intimately and mutually connected with each other.

The killing power of a charge of shot, at a given range, depends upon the total energy contained in the pellets that actually strike the mark or piece of game, at the moment that they strike.

If we suppose the range to remain the same, the mark to be of small enough dimensions, and the cartridges to contain a different number of pellets of the same size, then the number which strike the mark will be proportionate to the total number in the charge in each case, if their spread from the same gun is independent of the total weight of the shot charge.

It is, therefore, advisable, from this point of view, to have as many pellets as possible in the charge. On the other hand, the greater the weight and diameter of each pellet, the higher is its actual remaining velocity for a given range, at the moment it strikes; consequently, this latter condition is the one which limits the maximum number of pellets for a certain weight of charge in order to obtain a given range and killing power.

Experiments to ascertain the killing effect all tend to conduce to the use of as heavy a charge of shot as possible, composed of pellets heavy enough to have a high remaining velocity when they strike the object. On the other hand, the muzzle velocity and weight of gun must be so proportioned to each other and combined, that the recoil energy does not exceed a certain amount. These three are the elements, the most effective combination of which have to be investigated and determined.

Most people who have either studied or otherwise interested themselves in the subject have come to the conclusion that the weight of a shoulder gun for ordinary purposes should not exceed about 7lb. A gun weighing 9lb., for instance, though very useful for certain special purposes, would be too heavy a weapon to carry for several hours at the "ready" position; and the tendency generally is, if a gun is too heavy, either to carry it on the shoulder or over the shoulder by a sling, which is equivalent to saying that when a bird or beast gets up it is often able to get out of range before the sportsman is ready to fire.

Again, it is difficult to get a heavy gun on the object and to follow it in the same manner that is possible with a light one. In determining the "effective" power of a weapon this factor must be taken into account, since a piece of artillery would have much more latent power than a shoulder gun, but it would take so long to aim that it would never be ready until the object was out of range, and, therefore, for this reason would be much less "effective" than the shoulder gun. In the calculations that follow, 7lb is accordingly taken as the standard weight of the sporting gun.

In a former article (No. VII.), where the question of recoil was considered, it was laid down that only a few men could stand as much as 44 ft lb. recoil; for the ordinary sportsman it is, however, thought that the limit, even for strong men, should be 36 ft.lb., and that 29 ft.lb, as a rule, should not be exceeded by the majority of sportsmen.

Taking these figures and the 7lb. gun as our basis, the subjoined table shows the muzzle velocity with various weights of shot charge corresponding to 29 ft.lb. and 36 ft.lb. of recoil respectively with black powder.

Muzzle Velocity.	Energy of Recoil.	
	29 ft.lb.	36 ft.lb.
ft. sec.	Weight of shot.	Weight of shot.
820	1·9 oz.	2·2 oz.
984	1·5	1·7
1148	1·2	1·3
1312	1·0	1·1
1476	·8	·9
1640	·7	·8

Now the killing power of the shot charge is, as has already been stated, proportional to the energy contained in that portion of it which actually strikes the object; and, therefore, the combination of velocity and weight that gives the highest value to this energy at a given range is the most effective.

This value can be determined by means of the two tables which were compiled, the first to show the fraction of the total charge (for three different sizes of shot) which will strike a target 4in. square at different ranges; and the second to show the remaining velocity of the same sizes of shot at different ranges for different muzzle velocities. By means of these two tables a third one was made, which gives the actual remaining energies under the same conditions.

FRACTION OF SHOT CHARGE WHICH WILL STRIKE A TARGET 4in. SQUARE AT VARIOUS RANGES.

Ranges, Yards.	22	33	44	54	65
Shot B.B.....	·1114	·038	·018	·009	·0040
" No. 4 ...	·08	·028	·012	·005	·0029
" No. 8 ...	·058	·015	·005	·002	·0008

REMAINING VELOCITIES OF B.B., NO. 4, AND NO. 8 SHOT AT VARIOUS RANGES FOR DIFFERENT MUZZLE VELOCITIES.

M.V.	B.B. Shot. Ranges.					No. 4 Shot. Ranges.					No. 8 Shot. Ranges.				
	22yds.	33yds.	44yds.	55yds.	66yds.	22yds.	33yds.	44yds.	55yds.	66yds.	22yds.	33yds.	44yds.	55yds.	66yds.
f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.
820.....	636	561	492	433	374	593	501	420	347	293	472	364	292	249	220
980.....	761	670	590	354	456	708	603	506	426	354	557	426	334	272	236
1150.....	863	761	672	590	518	797	679	577	485	410	636	479	374	299	252
1310.....	948	838	735	652	571	873	741	633	535	449	699	521	400	315	262

ENERGY OF PELLETS STRIKING TARGET 4in. SQUARE.

Energy of Recoil.	M.V.	Weight of Shot.	B.B. Shot. Ranges.					No. 4 Shot. Ranges.					No. 8 Shot. Ranges.		
			22yds.	33yds.	44yds.	55yds.	66yds.	22yds.	33yds.	44yds.	55yds.	66yds.	22yds.	33yds.	44yds.
ft.lb.	f.s.	oz.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.	ft.lb.
29	820	1·91	81·7	22·6	8·08	3·19	1·24	52·5	13·1	3·91	1.25	·457	24·0	3·65	·792
	980	1·51	94·7	25·5	9·1	3·62	1·44	58·8	14·9	4·51	1·49	·535	26·7	3·95	·812
	1150	1·21	97·5	26·4	9·35	3·76	1·51	59·8	15·1	4·68	1·55	·572	27·7	·4·00	·833
	1310	1·00	97·2	26·0	9·40	3·76	1·51	59·2	14·9	4·65	1·55	·567	26·7	3·90	·775
36	820	2·19	93·5	25·8	9·25	3·63	1·42	59·5	14·95	4·45	1·43	·522	27·5	4·17	·905
	980	1·69	106	28·4	10·25	4·05	1·63	65·7	16·65	5·05	1·65	·598	29·8	4·41.	·930
	1150	1·36	110	29·2	10·7	4·23	1·7	67·5	17·05	5·26	1·75	·645	31·1	4·50	·925
	1310	1·12	109	29·7	10·5	4·23	1·7	66·7	16·8	15·23	1·75	·640	30·5	4·40	·875

The conclusions drawn from this table are:

1. That the muzzle velocity which gives the best results, having regard to the limit of recoil laid down, is about 1180 f.s.
2. That the velocity may vary as much as 100 f.s. on either side of this number without making a very great difference.
3. That the most effective muzzle velocity is a little higher for large than for small sizes of pellets.

Which lead, in their turn, to the result that for 29 ft.lb. energy of recoil and a gun weighing 7lb., with black powder the charge of shot should be 1·16oz., with a muzzle velocity of 1180 f.s.; while, for the higher limit of 36 ft.lb. of recoil, and the same m.v. the weight of the shot would be 1·3oz., or about. These charges are those suitable for a 16 and 14-bore respectively; but, as the latter is not a calibre of gun in general use amongst sportsmen, those who are afraid of a little extra recoil should use a 16-bore, the use of the 12-bore, throwing 1¼oz. of shot with 1100 f.s. m.v., being reserved for such sportsmen as do not mind its recoil, and whose desire, above all things, is to kill their game.

Such are the ideas of the French experimenters, on the advantages and disadvantages of the sporting shot gun of the present day. They then take a glimpse at the possible improvements of the future; for it is an undoubted fact that, as game gets wilder and wilder, which it is always doing, a weapon having a longer range than the present ones will be necessary, in order for it to be as effective.

There are three general methods by which the range of a gun can be increased:

1. By using a charge of shot more or less consolidated, but which will break up after leaving the muzzle, like the case shot of artillery.
2. By using a repeating arm, firing single projectiles rapidly one after the other.
3. By employing an actual shell, timed by a fuse to burst when required.

There are two elements which, it has been already decided, cannot for practical reasons be modified to any extent, these being the weight of the gun itself and its energy of recoil, which are fixed by the powers of endurance of the human being.

Since the weight of the powder charge has a considerable effect upon the recoil, it is obvious that here an improvement is possible, because the smaller the weight of the charge is the less will be the recoil, and, consequently, perfection in this respect would be reached when the weight of the charge was infinitely small. Such an explosive would permit of increasing the power of a weapon as above discussed by 25 per cent. without increasing its energy of recoil.

Again, if some metal heavier than lead were available for the manufacture of shot, the pellets would lose their velocity less rapidly, and a longer effective range would be possible. Platinum and tungsten would fulfil the conditions, but they are both far too expensive, and the latter too hard to work to be of any practical use.

As was pointed out in Article VIII., the majority of sportsmen do not require a gun to shoot closer than those in common use, but, at the same time, a really good shot would be enabled to kill at distances now quite impossible with the ordinary gun, if he had a weapon that could throw its shot closer than this does.

Suppose, they say, one takes for example a gun giving a spread of only 50 per cent. of the normal; on a mark of suitably small size such a gun would put four times as many pellets in the pattern as the ordinary gun with an equal weight and size of shot charge. But, presuming that the pattern of the ordinary gun was good enough to kill, the pellets of the shot charge of the special gun might be increased to double their diameter, and, therefore, to four times their weight, without affecting the muzzle velocity, recoil, or total number of pellets striking the mark as compared with the ordinary gun; and under the different conditions the effective range would be some 50 per cent. greater.

The uncertain action of wire cartridges, concentrators, and such like devices has already been discussed; and the only certain method of reducing the spread would seem to be by causing the pellets of shot to leave the gun one after the other. This the chokebore actually does effect to a certain extent, but it has, as already stated, the disadvantage of deforming the pellets and giving them unequal velocities.

The description of breech mechanism or action of the gun, if well made, has not any practical effect on the regulation, but it influences the efficiency of the weapon in so much as it enables it to be fired more or less rapidly.

If the only theoretically perfect way to obtain the minimum dispersion is to project the pellets one after the other in succession, then a gun built to throw a number of tiny projectiles successively in a very short space of time would constitute a sporting arm of extreme accuracy and long range. Leaving the actual mechanical solution of the problem out of the question, say the French experimenters, one may quite reasonably picture to himself a gun capable of firing from 50 to 100 shots per second.

Though such a weapon exists at the present time only in theory, at any rate, the conditions it should fulfil and the advantages it would offer for long range fire may be discussed. The Maxim automatic gun, for instance, the mechanism of which is well known, could be utilised as an arm of this description. The ·433 Maxim gun fires ten cartridges, weighing 1½oz. each, per second; now, the rate of fire such guns may be taken approximately as inversely proportional to the weight of the cartridges, and, therefore, cartridges of a calibre of from ·07in. to ·12in., and having a bullet weighing from 3 to 4·5 grains could be in all probability fired at the rate of 100 per second by a gun of the maxim description. This number is the same as that contained in a charge of No. 3 (French size) shot, as fired from a 16-bore gun.

The Maxim mechanism is patented, but there are other lines for the inventor to work upon.

According to another plan the gun would be designed for the powder charge to be fired in a closed vessel when the trigger was pressed to fire; this vessel would be so proportioned to the charge that the maximum pressure could not exceed three tons per square inch. When the gas pressure reached a certain amount, it would

operate mechanism, similar, for instance, to that used in the syren, which would open and close a valve or orifice intermittently between the barrel and the chamber, and, at the same time, place the bullet in position in the barrel in the intervals between closing and opening.

Such a weapon, which would be beyond the range of possibility with black powder, on account of the fouling it produces, is by no means impracticable, the French experimenter considers, with the modern chemical smokeless explosives, many kinds of which are now known.

An automatic repeating arm, of 7lb. weight, firing a projectile of from 3grs. to 4·5grs., could fire one hundred such projectiles at least without affecting the aim in any important degree; and it is by no means improbable that the slight vertical deviation which would occur from the succession of shots being fired might not be actually an advantage, since it would compensate for any error in under-estimating the range and the curvature of the trajectory.

The bullet fired would be an elongated one, and the barrel, to give the necessary muzzle velocity, would not need to be more than from 6·5 to 10 inches long.

The bullet, if ·078in. in diameter and ·236in. long, would weigh 2·78grs., and, if fired with a muzzle velocity of 1150f.s., would have sufficient energy left to kill a hare at 300 yards; whereas a spherical ball of the same weight would not have this amount of energy left at 60 yards.

A larger gun of ·15in. bore, firing a projectile weighing 3grs., would be capable of killing an animal the size of a roebuck at 1000 yards; whereas the spherical shot of the same weight would not do so at more than 65 yards.

The recoil of a gun weighing 7lb, and firing 165 of the 2·78grs. bullets, would have a total recoil energy equal to that of the ordinary 16-bore, but the recoil would be much pleasanter, making itself felt as a steady push instead of a sharp impulse. The accuracy of the arm would be equal to that of the army rifle, up to 100 or 200 yards, and it would be capable of pouring an effective fire upon medium-sized game at several hundred yards.

The other method of increasing the range of the present sporting arm is to use a "Shrapnel" shell such as artillery employ, only in miniature. It is stated to be perfectly feasible to make such a miniature shell of from ·7in. to ·78in. diameter only, fitted with a tiny fuse set beforehand to open at the required range. The shot would then spread and be effective at 30 yards, as it is when fired from a gun in the ordinary way.

The above sketches of possible improvements which the French authorities have presented to their readers may appear somewhat bold perhaps, and many objections, they admit, might be raised against such arms, such as:

1. Their expense. To which they reply that there are so many expenses incidental to shooting nowadays that the cost of the improved arm will represent a quite insignificant increase in the cost per head of the game killed.

2. That they would only be of use for such game as duck, which are easily visible at 100 yards or more, and are up and away as soon as they detect the approach of man.

3. That, on account of their long-range powers, they are likely to be a source of accident, or, at any rate, of danger. To this the answer is that the same consideration will apply to sportsmen who fire buck shot, spherical bullets, or even elongated bullets, which will seriously injure a man at any range from 300 to 3000 yards.

4. Then, again, it may be said that the game will get wilder in proportion as the effective range of the firearm increases. Their reply to this is that the first possessors of long-range arms will profit by them, and have an advantage over others not so fortunate. The change from one arm to another takes place but slowly, and the game will only gradually become wilder.

Industry is always, they add, on its onward march. The muzzle-loader has been abandoned for the Lefaucheux breechloader; this, again, for the chokebore. Who can say that in place of the chokebore a more powerful weapon for certain purposes will not come into use?

Field, Feb. 18, 1893; Vol. 81, p. 223.

XIV.—THE RIFLE AND BALL GUN AS SPORTING WEAPONS.

THE pursuit of large game with a rifle is, generally speaking, a more exciting form of sport than the shooting of small game with a shot gun, since far greater presence of mind and much greater accuracy are required in the former case than in the latter.

With the rifle, the farther off the game is the greater must be the accuracy of fire, since at any range the permissible error must be limited by the dimensions of the body of the animal itself, and, therefore, as this is a constant quantity, the angular deviation will be smaller as the range increases.

We may assume that the greatest effective range of the ordinary shot gun is about 65 yards, for although the largest sizes of shot may be effective at distances greater than this—80 yards or more, for instance—yet at these ranges the pellets are so few and far between that the probability of even one pellet striking the object is remote.

Whereas, then, with a rifle the chance of hitting at any range depends upon the skill of the shooter and the perfection of his weapon, with a shot gun, up to a range of 35 yards, it depends almost entirely upon his skill; from this distance up to 65 yards, to a small extent upon his skill; and to a great extent upon his luck; between 65 yards and 100 yards, the chance of killing gets less and less, and is practically *nil* beyond the latter range.

Shooting with ball may be classed under two heads:

1. Forest shooting at short ranges, such as the pursuit of wild boar.
2. Long range shooting in the open, such as deer-stalking, &c.

Of the many descriptions of sporting arms made for the above purposes nowadays, only three typical ones will here be considered:

1. The double-barrelled smooth-bore gun, firing a bullet.
2. The Express rifle, which is in some respects the most powerful weapon in general use.
3. The repeating rifle, as exemplified by the Colt repeating carbine, an arm of considerably less power.

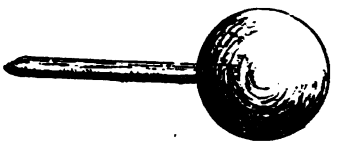
In France the double-barrelled smooth-bore gun is generally used for forest shooting, not, as will be seen later on, because it is the most fitted for this particular purpose, but more because it is equally useful as a shot gun, which a rifle, of course, is not.

The best projectile for a smooth-bore is a spherical bullet of either hardened or soft lead, it is of little consequence which, so long as it fits the barrel exactly. If the gun is a choke-bore, the bullet must, of course, be capable of passing freely through the choke, otherwise the barrels will be bulged or burst.

The bullets that one buys are often badly made, owing to the two halves of the mould not coinciding exactly; the head of metal is nearly always too short, and the consequence of this is that frequently there is an internal cavity in the bullet; the result being that the inaccuracy of fire, serious enough with a perfectly made bullet, is largely increased by these faults in manufacture.

The accuracy, however, can be increased, particularly at the longer ranges, by the introduction of a strong nail into the bullet mould when pouring the bullets. This "dodge" produces a projectile such as is shown in Fig 28. The end of the nail, when the bullet is in the cartridge, rests in the powder charge.

FIG. 28



During flight the shank prevents the rapid rotation which occurs with the ordinary bullet and is due to its eccentricity, and this "tailed" bullet would appear, from experiments made on paper screens, to oscillate only about 30° on either side of the tangent to its trajectory.

Roughly speaking, the greatest accuracy and killing power combined in a smooth-bore are obtained by firing the heaviest possible charge; the limits, therefore, are the strength of the weapon and the extent of the recoil permissible.

When loading a bullet in a cartridge, a greased wad should be placed over the powder charge, and the bullet itself should also be well greased.

The subjoined table for various guns shows the charges of powder and weight of bullet that will give three-fourths of their definitive proof pressure. Such charges, though they may be themselves used without risk, should not be exceeded, as they are the maximum ones; and they require that cartridges of good quality should be employed, otherwise there will be split cases and difficulties in extraction.

Nominal calibre	8.	10.	12.	16.	20.	24.	28.	32.
Weight of spherical leaden bullet in grains	925	712	599	458	369	310	262	203
Weight of maximum charge of No. 0 Fr. powder in grains.....	216	168	122	100	91	69	58	49
Muzzle Velocity, ft.-sec.	1424	1410	1302	1315	1384	1306	1292	1332
Weight of gun, lb.....	13	8·8	7·16	6·7	5·3	4·8	4·6	4·4
Energy of recoil, ft.lb.	83·7	73·0	50·8	34·4	33·3	22·2	16·3	11·5

With such charges as are shown in the above table the recoil of a 12-bore is severe, and that of an 8-bore almost unbearable. To obviate this excessive recoil the charge of powder must be lessened; but in order that a 10-bore may have an equal recoil to a 16-bore, the muzzle velocity of the former would have to be reduced to 985 f.s.; but then the energy of the bullet, which is the measure of its killing power, would be reduced to 535 ft.lb., whereas the energy of the 16-bore bullet is 755 ft.lb. with its ordinary full charge. Consequently, if the amount of recoil is taken into account, there is no advantage in the larger bore.

The best smooth-bore gun to use for ball is considered by the experimenters to be a 16 or 20-bore, with a weight of about 7lb.

It may be remarked, *en passant*, that when the smooth-bore was used for war purposes, the size of the bullet adopted by all nations was somewhere between these two limits, and time-honoured experience has proved that this size is the one which harmonises best with the powder and the power of man, and at the same time produces the greatest effect.

The accuracy of the spherical bullet with the nail cast in it is more than twice as great as that of the bullet not so provided, at ranges of from 100 to 200 and more yards; on the other hand, a rifled bullet is ten times as accurate as a smooth spherical one at 100 yards, and fifty times so at 500 yards.

All smooth-bores, whether long or short, single or double-barelled, give practically the same results as regards accuracy, if their bullets fit them properly; but if the bullets fit loosely, then a thin, light barrel will give worse results than a thick one.

The accuracy, too, if almost independent of the calibre, though it is slightly greater as the charge increases—a fact which is more especially noticeable at the longer ranges. An elongated or conical bullet fired from a smooth-bore gives, as one would naturally expect, a far worse result than a sperical one, as regards accuracy of fire.

The general tendency with sportsmen is to employ too small a powder charge when firing bullets; this practice leads to certain dangers which should be more widely known. If a spherical bullet strikes an obstacle in its flight, it will have a greater tendency to rebound; or to glance off at a greater angle, as the velocity decreases, with which it is travelling at the time of meeting the obstacle. For instance, a spherical bullet striking a piece of hard wood, such as elm, oak, &c., with a velocity of less than 650 f.s., will glance off at a considerable angle, and sometimes even recound direct. On the other hand, bullets travelling with a high velocity never glance to any great extent; for an obstacle whose inclination to the line of fire would cause a bullet moving at a low velocity to glance, would, if a hard substance, break up the same bullet when it was travelling at a high velocity. From this point of view, the smooth bore bullet, with its low velocity, is much more likely to cause shooting accidents than the high velocity bullet of the small bore rifle; and the opinion of the French is that the use of the smooth-bore gun and bullet for forest shooting should be abolished, if only on this account.

The penetration of a 16-bore bullet into pine plank at various ranges was found to be as follows:

Diameter of hardened lead bullet, 16-bore, ·669." Weight of ditto, 458·3grs.

	Range.									Elevation of over 10 deg.
	Muzzle.	54	110	164	218	328	437	656	875	—
Remaining velocity, f.s.	1312	1083	958	873	804	692	590	446	353	256
Penetration into pine, inches	9·45	6·69	5·52	4·72	3·93	2·75	1·96	1·18	·669	·39

As regards the glancing or rebounding of a bullet. If the striking angle is between 10° and 45°, the bullet will glance at practically the same angle it struck at; if the striking angle is less than 10°, the glancing angle will generally be less than the striking one; but if, on the other hand, the striking angle be greater than 45°, then the glancing angle will be greater than the striking angle, and the ball may sometimes come back almost directly at the shooter.

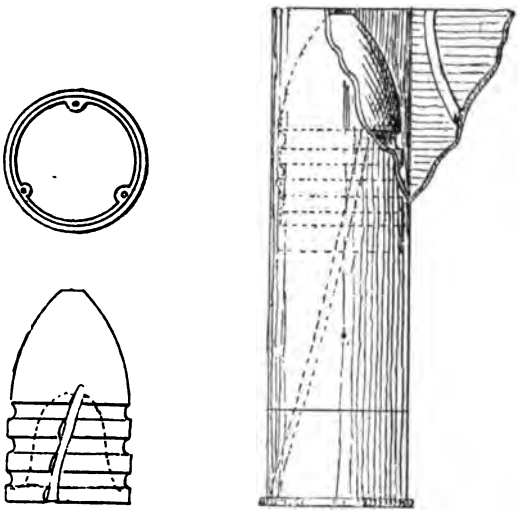
As was noticed with respect to shot guns, the heavier the charge of powder the lower the gun appears to carry. All the guns tried behaved in this manner; and it was also found that the right barrel generally carried to the right, and the left barrel to the left of the object the gun was laid on, with the service-charge.

A sportsman trying his gun with ball generally does so by firing a few cartridges at a bullseye on a target, and then measuring the mean distance of the point of impact from the centre of the bull; and when he finds that on firing a heavier charge this mean distance increases, he is apt to conclude that the extra deviation he observes is due to the increased charge instead of to the defective regulation of the gun, which is the true cause of it. This will explain, perhaps, why there is a strong tendency among sportsmen to put too small a charge of powder in their bulleted cartridges.

In reality, the mean deviation from the mean point of impact is less from a smooth-bore when a large charge of powder is used than when a comparatively small one is employed.

A form of "rifled cartridge" is made, in which the rifling takes the form of three ribs inside the cartridge case, as shown by the illustration (Fig. 29). These ribs give a movement of rotation to a

FIG. 29



conical bullet of the form depicted, which has itself three grooves on its exterior surface corresponding with the ribs of rifling. The bullet is thus given a rapid rotatory movement, which is sustained after it has left the gun, and is generally sufficient to keep its travelling point foremost. To obtain this result the bullet must not be any larger than the smallest diameter of the bore, nor must a heavy charge of powder be used (55grs of No. 1 French black powder is recommended for a 16-bore). Such cartridges give, experiments show, twice the accuracy of the ordinary spherical bullet; but there is this objection to them, that they are liable to stick and occasion difficulties of extraction.

The question of firing buck shot of various sizes, and the effect produced thereby, is gone into at some length; but this is probably of not much interest to English sportsmen, and is therefore omitted.

The Express Rifle.

We now come to the second typical example—the "Express Rifle." These rifles are stated to be generally of English manufacture, the best known being the ·450 and ·500 bore. Two of Greener's make were used for the experiments, their respective measurements and details being as follows:

	·450-bore.		·500-bore.
Weight of rifle	8·10lb.	.....	8·22lb.
Total length of barrel	26in.	.....	26in.
Capacity of cartridge case	·4150 cub. in.	.....	·5306 cub. in.
Diameter of bullet before firing	·454in.	.....	·500in.
Diameter of bullet after firing—			
Over the lands	·441in.	.....	·492in.
Over the grooves	·449in.	.....	·500in.
We ght of bullet	275grs.	.....	343grs.
Length	·886in.	.....	·886in.
Number of grooves	6	.....	6

The bullets were pressed ones, and the lead slightly hardened; they had a central hole occupying about two-thirds of their length; this hole is closed in front by a small copper tube, and its object is to assist the spreading out of the bullet when it strikes.

The muzzle velocity of the ·450 bore with 108grs. No. 1 (French) black powder was 1820 f.s., whilst that of the ·500-bore with 139grs. was 1900 f.s.

The experimenters state that the accuracy of such weapons is not and cannot be very great, because of the shape of the bullet and its high velocity; and that after four or five shots have been fired the leading is excessive. The shooting, they consider, might be much improved by more suitable cartridges and loading; as they stand now, they are of little use for sporting purposes beyond 150 yards, and at such ranges many army rifles are much to be preferred.

Repeating Rifle.

The third type is the repeating rifle. The pattern experimented with was the Colt repeating carbine,* weighing a little over 6½lb. and of ·420in. calibre; the muzzle velocity, with a 37grs. charge of black powder and a 208grs. bullet ·629in. long, was about 1312 f.s. In accuracy and trajectory it was found to be much inferior to the army rifle, and, taken all round, it is said to be a very moderate weapon of small power, and, moreover, uncertain in its action.

There are many other repeating sporting rifles; in particular, the various sizes and kinds of Winchester carbines; these, speaking generally, as far as their powers are concerned, occupy an intermediate position between the Colt carbine and the "Express" rifle.

Sporting arms firing ball ought to satisfy pretty nearly the same conditions as the weapons used for military purposes. As a rule, however, it is not the most appropriate weapons that are used for sporting, and in a great many instances the very qualities essential to obtaining the maximum useful effect will be found deficient.

The first and most indispensable quality that a weapon firing a bullet should possess, is that of working with certainty. A weapon that misses fire, or whose cartridges will not extract, is always a source of annoyance, and sometimes even of actual danger, to its owner.

There is, unfortunately, scarcely a weapon in existence which can be said to be entirely free from all these defects, and the repeating arms in the market for sporting purposes are specially open to objection on this score.

The double-barrelled rifle is much to be preferred to either a single-barrelled one or a repeater at close quarters; for, if the first shot does not kill, there is frequently not sufficient time to reload the single barrel, or even the repeater, before the animal is upon the shooter. In open ground, at greater distances, this point is not so important, and the single barrel is preferable on account of its greater accuracy.

The killing power of projectiles differs considerably, from the mere fact that different animals have different degrees of sensitiveness, as it were, to wounds. Small deer and large birds, for example, may be killed by a comparatively small wound produced by one pellet of large grain of shot; but the following considerations of what a bullet should be capable of doing will be based upon the conditions it must fulfil when used against dangerous animals, such as wild boar, tigers, and other large game.

For all velocities within the limits of present practice, the bullet may be made either of pure lead, hardened lead, or lead with a metallic envelope, without any difference as far as the softer portions of an animal are concerned.

In every case it may be said that if the velocity is below 200 f.s. a bullet will fail to cut an artery or nerves, and will only bruise them should it touch. The striking velocity of a bullet should never, if possible, be below 1150 f.s.

A bullet whose striking energy is high will cause certain and instant death should it strike the bones of the upper part of the head or the spinal column.

The effect of a bullet having a very high velocity striking a bone is not only that it shatters the bone, but also that it is itself broken up, and the fragments of bone and bullet penetrate the surrounding parts with an almost explosive effect, in some cases even producing large holes on the opposite side of the animal to that on which the bullet entered.

Practically, from their lesser recoil, small-bore rifles are more suitable than large ones for these extremely high velocities; the energy contained in a bullet, even though a small one, may be considerable, since, though it only varies in simple proportion to and directly as its weight, it varies as the square of its velocity.*

From experiments made on soft-skinned animals, it would appear as if the penetration in the softer portions of an animal were almost proportional to the energy per unit of sectional area of the bullet.

The minimum energy which a bullet must contain to pierce the skin of ordinary wild beasts (leaving out of the question those whose integument is exceptionally strong and hard, as, for instance, hippopotamus and crocodile) may be represented by the following equation:

(I.) $$\frac{E}{S} = \frac{W}{530}$$

where E = Energy of bullet on striking in ft.lb.
S = The sectional area of the bullet in square inches.
W = Weight of animal in lbs.

When the energy per unit of area $\frac{S}{E}$ is less than a 530th part of the weight of the animal, the effect will be only a more or less severe bruise.

The energy, however, on the bones is proportional to the total energy, and the projectile will enter and sometimes split them when

(ii.) $$E = \frac{W}{33}$$

But, to make certain of breaking any of the bones of an animal, it is advisable that the bullet shall have such a velocity that

(iii.) $$E = \frac{W}{16{\cdot}25}$$

When

(iv.) $$E = \frac{W}{3}$$

not only are the bones smashed, but considerable havoc is made of the adjoining parts. And, finally, when the energy rises to such a value that

$$E = {\cdot}75\ W$$

then the effects produced are similar to those which might be made by an explosive substance.

From the above statement it would appear, therefore, that to kill an animal at all it is necessary to use a weapon and projectile of such power that the numerical value of the striking energy of the projectile in ft.lb. is not less than $\frac{1}{165}$ of the weight in lb. of the animal it is desired to kill.

A few extracts are given from the very complete tables that were drawn up to show the minimum values under the three different conditions laid down for velocity and weight of bullet to produce the required effects on various animals, from the size of a partridge to that of an elephant.

Weights and Minimum Velocities of Lead Projectiles Fired from a ·444-Bore Satisfying the Conditions of

$$(I.)\ \frac{E}{S} = \frac{W}{530}$$

	Partridge.	Hare.	Wild boar.	Horse.	Elephant.
Weight of animal, lb.	·77	7·7	77	770	7700
Striking velocity. ft.sec.	Weight of projectile in grains.			Weight of projectile in oz.	
656	·108	1·08	10·8	·24	2·44
984	·046	·46	4.6	·107	1·07
1312	·031	·31	3·1	·061	·61
1640	·015	·15	1·5	·038	·38
1968	·01	·12	1·2	·06	·27
2296	—	—	·9	·02	·20

* The energy E in ft.lb. contained in a bullet of W lb. weight moving at a velocity of V feet per second, is equal to

$$\frac{W\ V^2}{2g}$$

g being the accelerating force of gravity, which may be taken approximately at 32·2 feet per second.

*With reference to the above remarks, under the head "Repeating Rifle," the manager of Colt Company's London Office, in a letter to the *Field* the week after the publication of this article, wrote as follows:—"It would appear as if our small ·44 calibre carbine had had the honour of having been tested and reported on in France as a sporting arm. If this is so, allow me to say that, as far as our carbine is concerned, this report can scarcely apply to it. It is described therein as of ·490 calibre, taking 37 grains of powder and a bullet of 208grs., whereas its calibre is ·440, it takes 40grs. of powder, and a bullet of 200grs.; that is to say, it takes our ordinary 'Frontier Pistol' cartridge, and, therefore, this carbine is never sold by us as a sporting arm, but for house and personal defence, especially when travelling on horseback in unsafe countries, hence it always is provided with a ring for attachment to the saddle. Furthermore, this weapon has of late been made to weigh 5½lb., not 6½lb., as stated in the report, which appears to indicate that an obsolete pattern of Colt's carbine has been tested with ammunition of a character to us unknown and differing from ours; and as, for the satisfactory working of a magazine arm, proper cartridges are a necessity, we cannot accept this report as of any value as far as our magazine rifles and carbines are concerned."

WEIGHTS AND MINIMUM VELOCITIES OF LEAD PROJECTILES FIRED FROM A ·444-BORE SATISFYING THE CONDITIONS OF—*continued*.

(III.) $E = \frac{W}{16 \cdot 25}$

	Partridge.	Hare.	Wild boar.	Horse.	Elephant.
Weight of animal, lb.	·77	7·7	77	770	7700
Striking velocity. ft.sec.	Weight of projectiles in grains.			Weight of projectile in oz.	
656	·529	5·29	52·9	1·27	12·7
984	·236	2·36	23·6	·54	5·4
1312	·132	1·32	13·2	·31	3·1
1640	·084	·84	8·4	·19	1·9
1968	—	—	5·88	·13	1·3
2296	—	—	4·32	·098	·98

(IV.) $E = \frac{W}{3}$

656	2·48	24·8	248	6·0	60
984	1·17	11·7	117	2·6	26
1312	·88	8·8	88	2·0	20
1640	·41	4·1	41	·97	9·7
1968	·29	2·9	29	·67	6·7
2296	·216	2·16	21·6	·49	4·9

The above tables serve as a guide to the manufacturer as well as to the sportsman, inasmuch as they lay down what power is required to produce certain results in each case. As regards the arms in actual use, the following table shows their comparative power :—

Description of Gun.	Calibre. Inches.	Bullet.		
		Weight in lb.	Velocity at 27 yards.	Energy in ft.lb. at 27 yds.
Double-barrelled gun, 32-bore...	·512	·0288	1118	563
,, ,, 28-bore...	·559	·0374	1102	708
,, ,, 24-bore...	·590	·0443	1129	875
,, ,, 20-bore...	·626	·0526	1220	1210
,, ,, 16-bore...	·673	·0654	1168	1390
,, ,, 12-bore...	·732	·0855	1171	1820
,, ,, 10-bore...	·779	·1018	1293	2640
,, ,, 8-bore...	·850	·132	1325	3620
,, ,, 4-bore...	1·023	·213	1312	5720
Colt carbine, repeater	·433	·029	1256	716
Express rifle, ·450	·443	·039	1772	1900
,, ,, ·500	·492	·0487	1739	2290
French Army Rifle, 1874 pattern	·433	·0551	1410	1700
Rifle, ·314 calibre	·315	·033	2057	2170
Army revolver, 1874 pattern	·433	·0255	505	101

The 32-bore, the least powerful arm (excepting the revolver), is, it will be seen, sufficient to kill wild boar, wolves, or deer, the largest wild beasts met with in France. The ·450 Express, the 1874 pattern rifle, and the double-barrel 12-bore gun should give excellent results against animals weighing up to 550lb. Whereas the ·500 Express, the ·314 rifle, and the 10-bore gun are powerful enough to kill animals of the weight of a horse or 770lb.

For the largest animals—the elephant, for instance—a double 4 or 8-bore would be most suitable ; for with a less powerful weapon—the 1874 rifle, for example—he might be riddled with bullets before being killed, except by a lucky chance.

A revolver is not a safe weapon to employ to stop an animal of even the small weight of 110lb. ; the bullet of a comparatively powerful revolver will barely perforate the bones of a human being.

While upon this question, it may be interesting to remark that buckshot may be used with success for hunting wild boar, and will kill them at 60 yards range. For a 16-bore gun the size of the shot should be such that three will lie in each layer, each shot will then weigh about 45grs. ; and similarly for a 12-bore they should lie in layers of four, the shot weighing about 60grs. each.

The advantage gained by substituting buckshot for a bullet lies in the extra chance of hitting the animal with the former, owing to their spread and to the accuracy they have in comparison with the spherical smooth-bore bullet.

The bullet of the Express rifle has a central hole closed by a copper cap, and this central hole allows of the bullet opening out a little more readily than if it were solid ; but this effect is to a great extent dependent upon the resistance afforded by the object it strikes. The effect on a bullet, such as shown in Fig. 30, when fired at pine and oak respectively, in shown in the figures 31 and 32.

From an all-round point of view, there is not much advantage in the central hole, for although it may occasionally and in exceptional cases increase the killing power, yet it has the disadvantage of decreasing the possible accuracy of fire by the unavoidable imperfection in the centring of the bullet.

Steel-pointed lead bullets, although generally believed to have greater penetration than lead bullets into hard bodies, in reality have not ; the reason for this being that, at the moment of striking, the lead envelope or base slips over the steel head, and the effect is therefore only that due to the separate action of the two parts and their respective momenta. A lead bullet with over 1300 f.s. striking velocity will pierce the hide or covering of any animal.

Explosive bullets are sometimes met with. They are generally of large calibre, and, when they do explode in the soft parts of an animal, are very effective ; but their action in this respect is very uncertain, and, when fired at a high velocity, they may be even dangerous, on account of their liability to burst in the bore. When they explode against a bone, they do not produce a greater effect than a solid lead projectile of equal weight, provided the latter has a velocity of over 1650 f.s. There is, in fact, very little to be said in favour of their use.

FIG. 30

FIG. 31

FIG. 32

The height of the trajectory of a gun or rifle is an important point in some instances. In a wood or forest, or for ranges up to 60 yards, the trajectory of the weapons in general use is quite flat enough ; but for longer ranges in open country, and especially over 200 yards, the height of the trajectory is one of the most, if not the most, important point, from the fact that it is practically impossible for anyone to judge distances with accuracy, however skilled and practised he may be. The most skilled will make errors which in the mean will amount to one-eighth of the range over open ground, and to one-fifth of the total range if the ground is not open. The great majority of sportsmen, in estimating the range, will not uncommonly make errors greater in extent than the range itself. Supposing, for example, that the best judges, in estimating range, are liable to make errors amounting to 40 yards in 200, or 60 in 300 yards, this alone reduces their chances of hitting with an Express rifle by 50 and 80 per cent. respectively. The accuracy of an Express rifle is almost as good as that of the army rifle of 1874 up to 150 yards range, beyond which range it is less than that of the latter. The best weapon to employ in open country would, in the opinion of the experimenters, be the 8 m/m French army rifle of 1886.

The regulation of a rifle is almost as important as its inherent accuracy, and, strictly speaking, every rifle should be sighted by the man who is to use it, since each one has his own small peculiarities of aiming. The performance of a gun, too, with shot and ball is not by any means necessarily identical, the shooting with the latter being frequently extremely bad. It is a most uncommon thing to find an Express rifle both of whose barrels carry on the same spot. The best plan is to carefully adjust the sighting for the right barrel at the expense of the left, since the first named is the one usually fired, the latter being reserved for action at close quarters, where the greatest accuracy is not so necessary.

Generally speaking, the weight of a rifle may be a little more than that of a shot gun ; but, in order that accuracy may be obtained, the recoil should be moderate. The recoil may be put at 18 ft.lb. for long range sport ; for medium-sized animals, at closer ranges, 36 ft lb. ; and for very large beasts, 50 ft.lb. It is a mistake to use any weapon the recoil of which is felt to be excessive, as one is liable, from fear of the recoil, to involuntarily shrink at the moment of

firing, and thus disturb the aim. The following table gives a few data respecting the recoil of ball guns and rifles:

Description of Gun.	Weight in lb.			Muzzle Velocity in foot seconds.	Velocity of Recoil in foot seconds.	Energy of Recoil.
	Weapon.	Powder.	Bullet and Wad.			
Double-barrelled gun, 32-bore	4·41	·007	·032	1332	12·95	11·5
" 28 "	4·63	·008	·041	1292	15·05	16·35
" 24 "	4·63	·010	·049	1305	17·16	21·2
" 20 "	5·29	·013	·057	1384	20·14	33·3
" 16 "	6·72	·014	·071	1315	18·14	34·4
" 12 "	7·16	·017	·091	1302	21·35	50·7
" 10 "	8·82	·024	·108	1410	23·13	73·0
" 8 "	13·0	·03	·14	1424	20·4	84·0
" 4 "	19·84	·048	·216	1345	19·91	122·0
Express rifle..... 450 "	6·72	·015	·04	1870	16·46	28·2
" 500 "	8·15	·0198	·05	1837	18·07	42·0
·314 rifle (sporting).....	9·03	·0062	·034	2116	9·9	13·8
Army rifle, 1874 pat.	9·39	·0115	·056	1460	11·51	19·35

The recoil of a double 8-bore is actually painful, and renders really accurate fire an impossibility, whereas the recoil of a 4-bore gives a blow that may be considered as dangerous; the energy of recoil of one of these latter weapons, fired vertically downwards, is sufficient to lift a 10st. man 9in. off the ground.*

The recoil of a ·500 Express is painfully severe, but that of the ·450-bore can be withstood by the ordinary sportsman. From an examination and comparison, however, of the tables giving the recoils of the various arms, and the energies of their projectiles, it would seem as if the ·314-bore (8 m/m) and ·433-bore (11 m/m) offered the best solution of the problem of uniting a powerful energy of projectile with a moderate recoil.

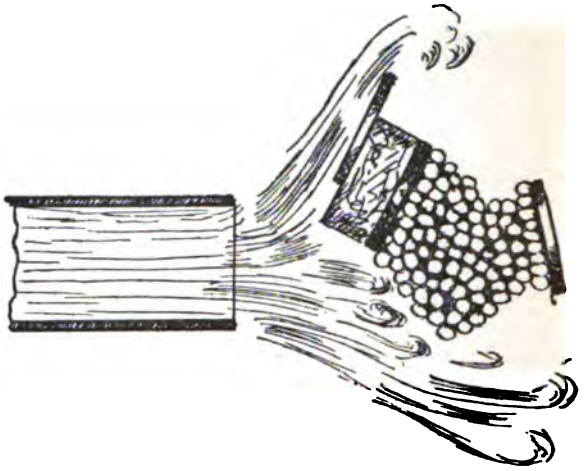
The French therefore consider that, for short ranges, such as obtain when shooting in forests or covert, a double rifle of one of the calibres mentioned above is the best to use with suitable cartridges; but for shooting in open country, a single barrel repeating rifle of like bore cannot be surpassed.

In concluding our series of articles on the French experiments with sporting arms, in which we have endeavoured to lay before our readers, in as concise and clear a form as possible, not only the results of, but the deductions from, the actual experiments, we cannot too fully express our appreciation of the masterly manner, and the careful and exhaustive way, in which Captain Journee, then Musketry Instructor at the Chalons Camp, has treated the whole subject in carrying out the task allotted to him by the French Government.

(*Field*, Sept. 16, 1893; Vol. 82, p. 447.)

THE DISPERSION OF THE SHOT CHARGE.

UNDER the above heading (in an article on "French Experiments with Sporting Arms," reprinted *ante*, p. 300) the following statement was made: "Turning now to the shot charge, at the moment of its leaving the gun, the forces acting upon it are as follows: On the one side there is the pressure of the powder gases, tending to overcome the inertia of the mass of lead, and on the other there is the resistance of the air in front of the charge, acting in the opposite direction. The consequence of these actions is that the shot charge, which has no cohesive powers of its own, spreads itself out somewhat in the manner shown in the illustration, which represents the shot charge just after leaving the muzzle of a cylinder-bored gun. This explains why the rear and outside pellets fly off in the most divergent lines."



When the above statement was first brought to our notice, we felt that far too much importance was attached to the action of the powder gases issuing from the muzzle, technically known as the "blast," causing the dispersion of the shot charge; but, knowing the anomalies which so frequently occur in the science of gunnery, we allowed the statement to pass without comment until we had had an opportunity of solving the question by direct experiment. Having recently made many experiments, we are now in a position to state that, practically speaking, the blast is not responsible for the dispersion of the shot charge.

As above stated, many experiments were made, but perhaps the one about to be described is sufficiently conclusive.

A 12-gauge cylinder-bored barrel was taken, and the average pattern with 1½oz. of No. 6 shot, in a 30in. circle at 40yds. was found to be 120. Four large square holes were then cut in the walls of the barrel, as shown in the illustration below, the mean distance of these holes being 4in. from the muzzle.

These holes were cut to allow the imprisoned powder gases to escape before the shot charge left the muzzle.

As the collective area of the holes was 20 per cent. in excess of the area of the bore of the barrel, the powder gases found a ready means of escape, and the blast issuing from the muzzle was reduced almost to nil. Under these circumstances, if the first-quoted statement was correct, the pattern on the target would be considerably increased; but upon trial it was found that no improvement had taken place.

As a further proof that the blast issuing from the muzzle of a shot gun has little to do with the dispersion of the shot charge, the following facts may be stated.

Take a gun, and load it with a small charge of fine grain black powder, and test it for pattern; then load it with a larger charge of coarse-grained powder, so as to obtain the same muzzle velocity. Now, it will be found that the coarse-grained powder will give a better pattern than the fine-grained powder, and this in spite of the fact that the blast of the powder gases from the muzzle is far more intense when the coarse-grained powder is used.

* The following are the details of a rifle considered suitable by the author for elephant hunting:

Weight of bullet	·86oz.
Weight of smokeless powder	100grs.
Muzzle velocity	2706 f.s.
Velocity at 27 yards	2625 f.s.
Energy at 27 yards	5770 ft.lb.
Weight of rifle	13·22lb.
Diameter of bore	·4016in.
Length of bullet 83 calibres	1·2in.
Velocity of recoil	15·25 f.s.
Energy of recoil	47·7 ft.lb.

The bullet would be of lead, encased in a metal envelope. Such a rifle would be more powerful, as regards the striking energy of the bullet, than the 4-bore, and would have the advantage, also, of less weight and less than half the recoil of the latter.

THE "KICK" SENSATION OF RECOIL.

(*Field*, Dec. 10, 1892; Vol. 80, p. 915.)

MANY practical sportsmen have long maintained, from the sensations they have experienced on the shoulder, that some powders make a gun kick more severely than others, even though no greater killing power may be imparted to the shot. But it is not easy to demonstrate sensations which are felt upon one's nerves; the nerves of all persons are not equally sensitive; and the assertion is not unfrequently made that inasmuch as action and reaction are equal, the gun which kicks most must shoot hardest.

Since recoil-gauges have come into use with sporting guns, it has been demonstrated that there are wide differences in the amount of recoil shown by various kinds of black powder, and still wider differences between black powders and nitro-compounds; and the mechanical rest described in the *Field* of Sept. 20, 1890 (and here reprinted at page 122), indicates the extent of these variations with greater precision than any other method which has come under our notice. Yet we are of opinion that no machine of this description (and the same may be said of scientific formulæ based on the velocity and weight of the projectile), however accurately it may record the *quantity* of the gun's recoil, can give a correct representation of the *quality* of the blow that produces the sensation ordinarily known as the "kick." The machine or the formula merely indicates the total amount of energy exhibited in the recoil, but fails to represent the characteristic jerk or blow that ordinarily distinguishes a quick-burning powder from one of slower combustion.

Upon the difference of speed in the back-thrust of a gun depends the amount of "punishment" given to the shoulder; and the difference in the sensation of the "kick" may be considerably greater than any mere variation in the amount of recoil registered by a method which gives only a total result.

With the purpose, if possible, of tracing out cause and effect, and thereby analysing, so to speak, the different sensations of recoil, we carried out, a year or two ago, some investigations by a simultaneous application of chronograph and recoil-gauge. By measuring the time occupied in the recoil of the gun for the space of a quarter-inch, half-inch, and inch, we found marked differences in the speed of the back-thrust with different powders; and it appeared that the culminating velocity of recoil with a 7lb. gun, loaded with 3drs. of black powder and 1⅛oz. of shot, was about 18 ft.sec., varying more or less according to the grain of the powder, No. 2 giving the highest and No. 6 the lowest result of the three kinds we tried. With 42grs. of nitro powder, fired under similar circumstances, the recoil was about 15 f.s., and the differences between Schultze, E.C., and S.S. were so small as to be immaterial. The records which we obtained for the quarter-inch times were not so satisfactory as we wished, and we accordingly abstained from publishing the results, as, after some repetitions, we saw no probability of improving on them by means of the chronograph in our possession, which would give but one record for every shot. Recently, however, we requested the assistance of Mr. R. W. S. Griffith, who has a more modern instrument, on the tuning-fork principle, the invention of the Rev. F. J. Smith. This instrument enables a succession of records to be obtained from each round fired; and for our purposes Mr. Griffith took records of three black powders and one nitro-compound, these records including the time of movement of charge in the 30in. barrel (*i.e.*, from blow on the cap to exit of shot), the time taken by the shot in traversing the first 5 yards after leaving the gun, and the times taken by the gun in recoiling one inch, in four subdivisions of ¼in. each. Before the gun had recoiled an inch, the charge of shot was out of the barrel with all the powders—viz., No. 2 black at about the half-inch; No. 4 and No. 6 between a half and three-quarters; and with Schultze just about the three-quarters. In each instance the velocity of recoil continued to increase after the shot had left the barrel, owing to the outrush of the products of combustion; but, as in the black powder these are twice as heavy as in the nitro-compound, the acceleration with the former was much more strongly marked.

The following tables will show the times of recoil for the respective quarter-inches, to which we add the corresponding velocities, and the energy of recoil of a 7lb. gun when moving at those rates of speed:

VARIATION OF RECOIL RECORDS WITH DIFFERENT POWDERS.

RECORDS.	No. 2 BLACK.	No. 4 BLACK.	No. 6 BLACK.	SCHULTZE POWDER.
	Time. Sec. / Velocity. Ft.sec. / Energy. Ft.lb.	Time. Sec. / Velocity. Ft.sec. / Energy. Ft.lb.	Time. Sec. / Velocity. Ft.sec. / Energy. Ft.lb.	Time. Sec. / Velocity. Ft.sec. / Energy. Ft.lb.
First ¼ inch of recoil	·00186 = 11·200 = 13·64	·00204 = 10·212 = 11·34	·00222 = 9·384 = 9·57	·00266 = 7·832 = 6·67
Second " "	·00120 = 17·361 = 32·77	·00122 = 17·076 = 31·71	·00124 = 16·800 = 30·67	·00134 = 15·547 = 26·28
Third " "	·00114 = 18·275 = 36·31	·00116 = 17·960 = 35·07	·00118 = 17·655 = 33·89	·00126 = 16.534 = 29·73
Fourth " "	·00114 / ·00534 = 18·275 = 36·31	·00120 / ·00562 = 17·361 = 32·77	·00124 / ·00588 = 16·800 = 30·67	·00136 / ·00662 = 15·320 = 25·21
Movement of charge from breech to muzzle	·0031 sec.	·0037 sec.	·0042 sec.	·0050 sec.
Mean velocity of shot for 5 yards from the muzzle	1289 ft.sec.	1145 ft.sec.	1103 ft.sec.	1151 ft.sec.

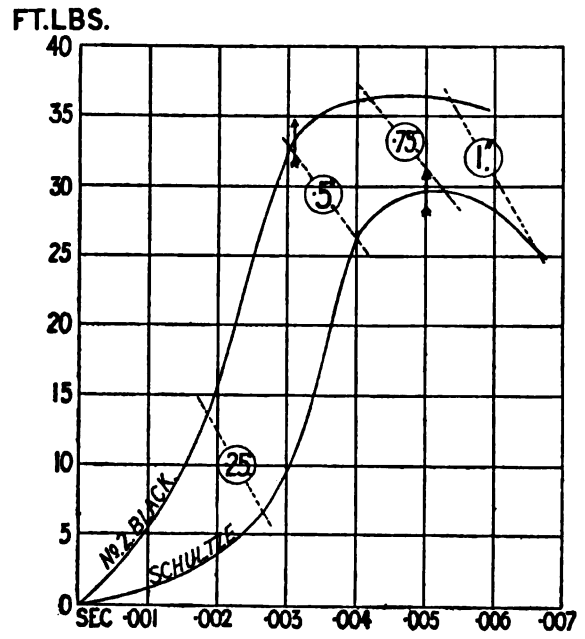
According to the old-fashioned formula for estimating recoil which is set forth in the Government "Treatise on Military Small Arms, 1888," page 31, the greatest velocity of recoil with a 7lb. gun and 1⅛oz. of shot, when the muzzle velocities are similar to those stated above, would be about 13 f.s. with No. 2 black, and about 12 f.s. or under with the other three powders; while the corresponding energies would not amount to one half of what is shown in the above tables. These wide differences of result are to be accounted for by the fact that the velocity of recoil is considerably increased by the outrush of gases and other products of combustion after the shot has left the muzzle of the gun, and that these powder products are not taken into consideration in the old formulæ, though they have been in some modern ones. For instance, in the French formula (results of which are shown in a table in Article VII. on "French Experiments with Sporting Arms (*ante*, page 299), the velocities and energy recorded have a close similarity to those given in the above table. But the results we have here stated do not accord exactly with what would be calculated from the same data on the French principle; and it would seem as if some variation in the co-efficient would be required with each of the powders we used—the slower the combustion of the powder the higher being the requisite co-efficient.

The records given on our mechanical recoil-gauge, with the same charges as were fired by Mr. Griffith in his experiments, gives about 35 ft.lb. with No. 2 Black powder and about 29 ft.lb. with Schultze. These figures differ but little from those stated in the above table for the third ¼ inch of recoil, which generally represents the culminating point of velocity and energy. Beyond that point the recoil gradually dies away, but it falls off sooner with the nitro than with the black powders, owing to the lower density of the powder products before alluded to. No. 4 and No. 6 Black powder ordinarily give, on this recoil-gauge, about 33 ft.lb. and 31 ft.lb. respectively; but all the powders vary somewhat on different days, and under different climatic conditions; and the extent of the variation is greater with nitro powders than with black powders.

On referring to the accompanying diagram of curves, the difference in the incipient recoil produced by the two powders, and in the respective rates of increase (the *maximum acceleration* of the back-thrust of the gun being the exciting cause of the "kick"), the contrast of force exhibited will become much more obvious than is apparent from the mere statement in figures; as, during the brief interval of two or three thousandths of a second, the black powder develops an energy of recoil that is about four times as great as that shown by the nitro in the same space of time. Afterwards the nitro powder shows a great rate of increase, but, following on the slower movement, it then comes as the gradual development of a "push,"

instead of a sudden "kick." If, however, through a nitro-compound being over-dried, or being excited by a priming of black powder, an abnormal rapidity of combustion is developed, then the shot would be driven forward and the gun backward with much greater rapidity, and the maximum acceleration might be considerably greater with the nitro than with the black powder. In such a case the nitro curve on a diagram might assume a more vertical direction than is shown by black, and the physiological impression on the shoulder would be correspondingly severe, as many persons have had reason to know when they have met with a violent discharge from nitro powder.

In the diagram, the arrows indicate the period at which the shot quits the muzzle of the gun; and the encircled measurements



(25", &c.) show when the ¼-inches of recoil were completed by the respective powders.

We have not inserted in the diagram the whole of the black powders, as the increased number of lines might tend to confuse; but we may state that No. 4 and No. 6 would present curves of a very similar character to that shown by No. 2, though a little lower down in the scale.

EFFECTS PRODUCED BY THE FRICTION OF SHOT IN GUNBARRELS.

(*Field*, Aug. 27, 1898; Vol. 92, p. 370.)

MANY have been the discussions with reference to what are, by different persons, considered to be the best bores to use for ordinary game shooting, the best length of barrels to adopt, and the best sizes of shot to employ. We do not remember, however, ever to have met with any definite information relative to the amount of friction that occurs from the use of small shot in barrels of different gauge, and the influence which that friction has, either in the way of lessening the velocity of shot of different dimensions, or necessitating an increase of powder to overcome the retardation. Yet it is certain that there must be a considerable amount of friction in gunbarrels, especially those of narrow gauge, and that if this resistance be overcome by the use of additional powder, it must also be attended by increase of stress in the barrel and likewise greater recoil.

We have recently carried out some experiments for the purpose of ascertaining the nature and extent of the results produced, and we shall probably have more to say on the subject in future issues, as regards variations caused by differences in length of the barrels as well as by the use of different kinds of nitro powders; but the present article will be devoted exclusively to experiments that have been carried out with black gunpowder (C. & H. No. 4 T.S.), which was used in order to obtain the greatest possible regularity; for, whatever may be the result in the future, it must be admitted that at present there is no nitro-compound which is so little influenced by variations in temp rature, strength of caps, &c., as the old black mixture of "villainous saltpetre" and charcoal.

The guns used on the present occasion were of three bores, viz., 12, 20, and 28, all using ordinary paper cases. These gauges are rather wide apart; but we thought it desirable to avoid intermediate sizes, as it not unfrequently happens, when guns are close together in dimensions, that some of the records overlap one another, and it is not easy to decide whether certain effects produced are a direct result of the size of the gun or of some extraneous influence.

In order to obtain a standard of comparison, we used in each bore a flat-headed cylindrical bullet of solid steel, of the same weight as the shot-charge that was to be employed in the same gun; and, of course, where two shot-charges of different weight were tested in the same bore, there were two steel bullets of corresponding weight. Each of the bullets was turned to such a size as to be an easy sliding fit in the barrel for which it was made, and it was slightly greased, so as to pass through the tube with the least possible amount of friction, and thus provide a line of comparison with the shot charges, which were loaded with No. 4, No. 6, and No. 8 shot respectively. The cartridge cases were not turned over, as that would be likely to vitiate the results; and with black powder there is not the same necessity for a turnover as there is with nitro-compounds. Of course, as the steel bullet was an easy sliding fit, there would here be little or no friction, except such as was due to the wads alone; whereas with the shot cartridges there would be the friction of the pellets in the barrel as well as of the wads, and the friction would be increased with the length of the column of shot. The smaller the size of the pellets, the larger would be the number coming into contact with the inside of the barrel, and, consequently, the greater would be the amount of friction produced; moreover, the larger must be the increase of powder requisite to maintain the standard velocity. The increase of powder, too, necessarily increases the pressure of the gases in the barrel, as recorded by the crusher-gauge, and likewise adds to the amount of recoil. In printing these records, we have arranged the rounds in order of velocity, so as to facilitate comparison. The records of velocity and recoil were taken simultaneously with the same cartridge; but the pressure in the crusher-gauge necessitated the use of a separate cartridge.

The larger tables printed below give full details of the shooting with ten rounds of each of the steel bullets, and the corresponding cartridges loaded with No. 4, No. 6, and No. 8 shot of equal weight; but the main facts will be more readily grasped by reference to the following

SUMMARY OF AVERAGES.

	Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
12-BORE:			
1⅛oz. bullet and 73grs.	1168	33·5	2·55
" No. 4 " 80 "	1163	33·9	2·59
" No. 6 " 82 "	1168	35·3	2·68
" No. 8 " 84 "	1164	36·6	2·71
20-BORE:			
1oz. bullet and 63grs.	1162	27·2	3·06
" No. 4 " 72 "	1160	31·7	3·43
" No. 6 " 74 "	1168	31·9	3·56
" No. 8 " 77 "	1168	33·6	3·83
⅞oz. bullet and 61grs.	1168	22·7	2·45
" No. 4 " 69 "	1165	25·3	2·70
" No. 6 " 71 "	1166	27·3	3·01
" No. 8 " 74 "	1167	29·3	3·29
28-BORE:			
¾oz. bullet and 50grs.	1165	23·5	2·75
" No. 4 " 56 "	1167	25·1	3·11
" No. 6 " 56 "	1166	25·9	3·32
" No. 8 " 58 "	1170	26·5	3·52
¾oz. bullet and 46grs.	1166	17·5	2·61
" No. 4 " 50 "	1164	18·6	2·76
" No. 6 " 51 "	1168	19·5	2·98
" No. 8 " 53 "	1161	19·9	3·18

Where the same weight of shot was used in two bores (viz., ¾oz. in the 28-bore as well as in the 20-bore), it will be seen that the pressure was higher in the smaller gauge, although the charge of powder was much diminished.

12-BORE (CYLINDER); WEIGHT OF GUN, 7LB.; LENGTH OF BARREL, 30IN.

(Barometer, 29·95in.; Thermometer—Dry 63°, Wet 61°.)

1¼oz. Steel Bullet, with 73grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1176	34·0	2·67
1176	33·9	2·61
1172	33·8	2·58
1172	33·6	2·58
1172	33·5	2·55
1167	33·3	2·55
1163	33·5	2·52
1163	33·4	2·49
1158	33·1	2·46
1158	33·0	2·46
1168	33·5	2·55

Averages of 10 rounds.

1¼oz. No. 4 Shot, with 80grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1176	34·7	2·76
1172	34·2	2·70
1172	34·2	2·67
1167	34·0	2·67
1167	33·9	2·64
1163	34·6	2·58
1163	33·8	2·58
1158	33·4	2·46
1154	33·1	2·43
1141	33·0	2·40
1163	33·9	2·59

Averages of 10 rounds.

1¼oz. No. 6 Shot, with 82grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1176	36·0	2·88
1176	35·8	2·82
1176	35·7	2·76
1176	35·4	2·73
1167	35·1	2·70
1163	35·2	2·64
1163	35·0	2·61
1163	34·8	2·58
1158	34·9	2·55
1158	34·6	2·52
1168	35·3	2·68

Averages of 10 rounds.

1¼oz. No. 8 Shot, with 84grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	37·4	2·94
1176	37·3	2·88
1176	37·2	2·82
1172	36·8	2·73
1167	36·0	2·70
1163	37·0	2·70
1163	36·5	2·67
1158	36·1	2·64
1154	35·7	2·52
1149	35·5	2·52
1164	36·6	2·71

Averages of 10 rounds.

20-BORE (CYLINDER); WEIGHT OF GUN, 5LB. 14½OZ.; LENGTH OF BARREL, 30IN.

(Barometer, 29·94in.; Thermometer—Dry 70°, Wet 68°.)

1oz. Steel Bullet, with 63grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1176	27·7	3·18
1172	27·5	3·16
1167	27·2	3·14
1167	27·0	3·12
1163	27·5	3·06
1163	27·4	3·04
1158	26·8	3·00
1154	26·9	2·97
1154	26·8	2·94
1149	26·9	2·94
1162	27·2	3·06

Averages of 10 rounds.

1oz. No. 4 Shot, with 72grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1172	32·2	3·66
1172	32·0	3·54
1167	31·9	3·52
1167	31·8	3·48
1163	32·2	3·42
1158	31·6	3·42
1154	31·5	3·38
1154	31·4	3·36
1149	31·5	3·30
1145	31·1	3·24
1160	31·7	3·43

Averages of 10 rounds.

1oz. of No. 6 Shot, with 74grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	32·3	3·72
1181	32·2	3·70
1176	32·0	3·64
1172	32·1	3·62
1167	32·0	3·58
1167	32·0	3·54
1163	31·8	3·52
1163	31·6	3·46
1158	31·4	3·44
1154	31·5	3·38
1168	31·9	3·56

Averages of 10 rounds.

1oz. of No. 8 Shot, with 77grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	34·1	4·16
1181	33·8	4·10
1176	34·0	4·04
1172	33·8	3·98
1172	33·6	3·80
1167	33·7	3·76
1163	33·4	3·72
1158	33·3	3·66
1158	33·0	3·62
1154	33·1	3·50
1168	33·6	3·83

Averages of 10 rounds.

⅞oz. Steel Bullet, with 61grs. of No 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressur Tons.
1181	23·1	2·61
1181	23·0	2·58
1172	23·0	2·55
1172	22·8	2·52
1167	22·7	2·43
1167	22·5	2·40
1163	22·7	2·40
1163	22·5	2·37
1158	22·6	2·34
1154	22·3	2·31
1168	22·7	2·45

Averages of 10 rounds.

⅞oz. No. 4 Shot, with 69grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	25·8	2·76
1172	25·9	2·76
1172	25·7	2·76
1167	25·4	2·73
1167	25·4	2·70
1163	25·2	2·70
1158	25·0	2·67
1158	24·9	2·67
1154	25·0	2·64
1154	24·8	2·61
1165	25·3	2·70

Averages of 10 rounds.

⅞oz. No. 6 Shot, with 71grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	27·9	3·18
1172	27·7	3·12
1172	27·6	3·08
1172	27·5	3·06
1167	27·4	3·02
1167	27·2	2·97
1163	27·1	2·94
1163	27·0	2·91
1158	27·0	2·91
1149	26·7	2·88
1166	27·3	3·01

Averages of 10 rounds.

⅞oz. No. 8 Shot, with 74grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	29·8	3·48
1176	29·8	3·42
1172	29·6	3·32
1172	29·4	3·30
1167	29·0	3·28
1163	29·3	3·26
1163	29·3	3·24
1163	29·1	3·22
1158	28·8	3·22
1154	28·9	3·20
1167	29·3	3·29

Averages of 10 rounds.

28-BORE (CYLINDER); WEIGHT OF GUN, 5LB.; LENGTH OF BARREL, 28IN.

(Barometer, 29·70in.; Thermometer—Dry 70°, Wet 65°.)

¾oz. Steel Bullet, with 50grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1186	24·0	2·88
1176	23·8	2·85
1172	23·9	2·82
1172	23·7	2·82
1167	23·5	2·79
1163	23·6	2·73
1158	23·3	2·70
1158	23·2	2·67
1154	23·0	2·64
1141	22·7	2·61
1165	23·5	2·75

Averages of 10 rounds.

¾oz. No. 4 Shot, with 56grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	25·6	3·54
1181	25·3	3·40
1176	25·3	3·34
1172	25·2	3·18
1167	25·4	3·12
1163	25·0	3·06
1163	24·9	3·02
1163	24·8	2·91
1154	24 6	2·82
1154	24·5	2·64
1167	25·1	3·11

Average of 10 rounds.

¾oz. No. 6 Shot, with 56grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	26·5	3·70
1181	26·3	3·68
1176	25·8	3·52
1172	26·1	3·42
1172	26·0	3·30
1167	26·1	3·28
1158	25·4	3·28
1154	25·5	3·20
1149	25·8	2·94
1149	25·0	2·88
1166	25·9	3·32

Averages of 10 rounds.

¾oz. No. 8 Shot, with 58grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1186	27·0	3·72
1181	27·1	3·68
1176	26·8	3·58
1176	26·2	3·54
1172	26·6	3·50
1167	26·3	3·46
1163	26·8	3·46
1163	26·4	3·44
1158	26·0	3·40
1158	25·9	3·38
1170	26·5	3·52

Averages of 10 rounds.

¾oz. Steel Bullet, with 46grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1190	18·1	2·79
1181	18·2	2·73
1176	17·9	2·70
1172	17·6	2·67
1167	17·6	2·61
1163	17·3	2·58
1158	17·4	2·55
1154	17·0	2·52
1149	17·2	2·52
1149	17·0	2·46
1166	17·5	2·61

Averages of 10 rounds.

¾oz. 4 Shot, with 50grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1176	19 3	2·85
1176	18·8	2·82
1172	19·0	2·82
1172	18·8	2·76
1167	19·1	2 76
1163	18·6	2·76
1158	18 4	2·73
1158	18 0	2·73
1154	18·2	2·70
1145	17·7	2·67
1164	18·6	2·76

Averages of 10 rounds.

¾oz. No. 6 Shot, with 51grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1176	19·7	3·18
1176	19·6	3·12
1176	19·4	3·10
1172	19·9	3·04
1172	19·8	3·02
1167	19·5	2·97
1163	19·5	2·91
1163	19·4	2·85
1158	19·3	2·85
1154	19·0	2·79
1168	19·5	2·98

Averages of 10 rounds.

¾oz. No. 8 Shot, with 53grs. of No. 4 Black powder.

Velocity. Ft.sec.	Recoil. Ft.lb.	Pressure. Tons.
1181	20·6	3·28
1176	20·2	3·26
1172	20·3	3·24
1167	20·2	3·22
1158	20·0	3·20
1158	19·8	3·18
1154	19·5	3·16
1149	19·5	3·12
1145	19·4	3·08
1145	19·3	3·06
1161	19·9	3·18

Averages of 10 rounds.

It is not easy, however, in all cases, to estimate the extent of the increase by reference merely to the original figures, and we have therefore converted them into per-centages, based on the averages of 10 shots with the steel bullets. These velocities may be taken as practically the same, whether recorded with the bullets or the charges of No. 4, No. 6, and No 8 shot, as in all instances the powder charges were regulated with the view of producing velocities as near as possible to the standard of 1160 ft.sec.; and although individual rounds may be a little over or under the standard of 1160 ft.sec. (possibly owing to some slight variation in the strength of the caps), the velocity averages show very little variation, as will be observed by reference to the following

PERCENTAGES OF VARIATION.

12-BORE GUN, WITH 1¼OZ. PROJECTILES.

	Bullet.	No. 4 Shot.	No. 6 Shot.	No. 8 Shot.
Velocity	1·000	0·996	1·000	0·997
Powder charge	1·00	1·09	1·11	1·15
Pressure	1·00	1·02	1·05	1·06
Recoil	1·00	1·01	1·06	1·09

20-BORE GUN, WITH 1OZ. PROJECTILES.

	Bullet.	No. 4 Shot.	No. 6 Shot.	No. 8 Shot.
Velocity	1·000	0·998	1·001	1·001
Powder charge	1·00	1·14	1·17	1·22
Pressure	1·00	1·12	1·16	1·25
Recoil	1·00	1·16	1·17	1·24

20-BORE GUN, WITH ¾OZ. PROJECTILES.

	Bullet.	No 4. Shot.	No. 6 Shot.	No. 8 Shot.
Velocity	1·000	0·997	0·998	0·999
Powder charge	1·00	1·13	1·16	1·21
Pressure	1·00	1·12	1·16	1·25
Recoil	1·00	1·11	1·20	1·29

28-BORE GUN, WITH ¾OZ. PROJECTILES.

	Bullet.	No. 4 Shot.	No. 6 Shot.	No. 8 Shot.
Velocity	1·000	1·002	1·001	1·004
Powder charge	1·00	1·12	1·12	1·16
Pressure	1·00	1·13	1·21	1·28
Recoil	1·00	1·06	1·11	1·14

28-BORE GUN, WITH ¾OZ. PROJECTILES.

	Bullet.	No. 4 Shot.	No. 6 Shot.	No. 8 Shot.
Velocity	1·000	0·998	1·002	0·995
Powder charge	1·00	1·09	1·15	1·15
Pressure	1·00	1·06	1·14	1·22
Recoil	1·00	1·06	1·12	1·14

In the foregoing table, it will be seen that the steel bullets are made the standard of comparison, whether with regard to velocity, weight of powder, pressure or stress in the barrel, and amount of recoil. Thus, as regards the 12-bore gun, the weight of powder used to obtain the standard velocity with the bullet is represented by the number 1·00, while the charge required to impart similar speed to the charge of No. 4 shot is 1·09, or 9 per cent. more powder; with No. 6, 11 per cent.; and with No. 8 the increase is 15 per cent., whereas the difference in velocity is so trifling that it only amounts to a fraction of 1 per cent.

Very similar results occur with pressure and recoil records, which are also largely augmented, especially in the 20-bore. The increase is not quite so great in the 28-bore; but that may probably be due to the barrel being two inches shorter than in the two guns of larger gauge.

Here we may also call attention to the rather remarkable results exhibited when equal charges of shot were employed in guns of different gauge. It will be observed that ¾oz. bullets and shot-charges were used in both the 20-bore and 28-bore barrels. As previously shown, the velocities produced were practically the same throughout, so we need not repeat them; but the differences in the quantity of powder required to produce the same velocities in the two guns, and the increased amount of pressure in the barrel that accompanied the use of the diminished powder-charge in the 28-bore, are well deserving of notice; we accordingly set forth the per-centages in tabular form:

	With Bullet.	No. 4 Shot.	No. 6 Shot.	No. 8 Shot.
Charge of powder { 20-bore	1·00	1·13	1·16	1·21
Charge of powder { 28-bore	0·82	0·92	0·92	0·95
Pressure in barrel { 20-bore	1·00	1·10	1·23	1·34
Pressure in barrel { 28-bore	1·12	1·27	1·35	1·44

It will thus be seen that, although the powder-charge was always diminished in the smaller bore, yet the stress in the barrel was always increased.

Most of our readers are doubtless already aware that the pressure of powder-gases in small bores is usually much higher than in guns of larger gauge; but the fact is often overlooked that, unless such were the case, it would be practically impossible to impart the same velocity to the shot, owing to the increased friction of the pellets and the diminished area of pressure behind them. Thus, supposing the charge to be the same in both bores, and the area of the wad behind the shot in one case to be 20 per cent. less than it is in the other, there must either be an increase of pressure in the powder-gases or diminished velocity in the shot. For example, the area of the 12-bore is, in round numbers, about 20 per cent larger than the 16-bore, or 40 per cent. larger than the 20-bore; and, supposing that 1oz. of shot were used in each of the three bores, while the pressure requisite to impart the required velocity in a 12-bore were 2 tons per square inch, the pressure needed to impart the same velocity in a 16-bore would be 2 tons multiplied by 1·20 for the 16-bore, and 2×1·40 for the 20-bore, or 2·40 tons and 2·80 tons respectively, without allowing anything for the effects of friction in the barrel. Fortunately, however, in such instances, an equal amount of powder does not represent a constant amount of force; for the frictional resistance of the shot in the barrel causes increased energy to be developed by the explosive, and consequently, as shown in the last table, a reduction of about 21% of powder with the No. 4 shot, or 24% with the No. 6, or 26% with the No. 8, sufficed to impart the same velocity with the 28-bore, as was given by the larger charges of powder used in the 20-bore gun.

PROPORTION OF LENGTH TO BORE OF GUNS

WITH OLD AND NEW POWDERS.

(*Field*, Sept. 17, 1898; Vol. 92, p. 498.)

A GOOD deal has been said, from time to time, as to what is the best length of the barrel. In this country, more than two centuries ago—not long after the foundation of the Royal Society by King Charles the Second—a paper was read which gave an account of experiments that had been carried out with the view of improving the art of gunnery, among which was one wherein a very long barrel was used, and it was gradually shortened until it was found that the range of the shot was materially diminished. At the early part of the present century, the barrels of sporting guns were made much longer than they are nowadays. Colonel Hawker said:

> It was formerly the custom to make barrels, although so small as 14, 16, or even 22 in the gauge, of three or four feet in length; and now, since it has been ascertained that 2ft. 6in. will shoot equally well, at the short distance of a gunmaker's confined premises, many have gone too much to the other extreme, and cut them to 2ft. 4in., and less. The disadvantage of this is that even the best shots are more liable to miss; as, although we allow that a short gun, at a short distance, will kill as well as a long one, yet the latter gives you a more accurate aim, and considerably lessens the recoil, by which you shoot to a greater nicety, and with more steadiness. To avoid all extremes, I should recommend small barrels, never less than 2ft 8in., nor more than 3ft. in length.

In the middle of the last century, barrels were made of much greater length than those recommended by Colonel Hawker; and a good deal is said on the subject in a book entitled "The Art of Shooting Flying; containing Directions for the Choice of Guns, Experiments discovering the Excention of Barrels of Different Length and Bores, with many useful Hints for the Improvement of Young Practitioners." This book was written by T. Page, who was a gunmaker, clockmaker, and general factotum in the city of Norwich. In answer to a pupil, who inquires "What length of barrel would you advise to begin with?" the author says:

> It is necessary for any gentleman who shoots much to have two guns: the barrel of one about two feet nine inches, which will serve very well for the beginning of the season, and for wood-shooting; the other about three feet three inches, for open shooting after Michaelmas: the birds by that time are grown so shy that your shoots must be at longer distances. But if you intend one gun to serve for all purposes, then a three feet barrel (or thereabouts) I think most proper.

It is obvious from this that the wildness of game birds is not so modern an institution as many sportsmen imagine.

Particulars are afterwards printed of the trials of fifteen guns, varying in length of barrel from thirty inches to five feet. The numerical patterns are given at different distances between twenty and fifty yards; but as the trials were made with No. 4 shot, at sheets of brown paper the dimensions of which are not stated, it is not easy to form any estimate in comparison with modern guns. Suffice it to say, however, that the first gun tried, which had 30in.

barrels, averaged 208 pellets at 20 yards, 94 at 30 yards, 29 at 40 yards, and 20 at 50 yards. And the author says:

By the shoots made with this gun, you may easily perceive it is difficult to make two shoots alike: and therefore no certain judgment can be made of its goodness by two or three shoots. For instance, the shoots here made at forty yards are not much above half the number of shot there ought to be in proportion to those at twenty and fifty yards.

Of some of the guns tested, rather full details are given as to gauge, length of barrel, load, &c., whereas of others there is little beyond the length and weight. We summarise a few of the particulars, which may be of interest as showing not only the length of barrels, but the proportions of powder and shot then employed. Instead, however, of giving the size of the bore as stated in the book (*e.g.*, "the bore six-tenths and three-quarters diameter"), we give its modern equivalent, of 15-bore, and so on. All the guns are single barrels, as double-barrels did not come into general use until near the close of the century. Our summary of the guns described in Mr Page's book is as follows:

1. Barrel 2ft. 6in. long, 17 gauge, weight of barrel 2lb. 14oz., weight of whole gun 6lb. 2oz.
2. Barrel 2ft. 9in., 19 gauge, weight 3lb. 2oz., whole gun 6lb. 5oz. "The powder and shot took up 2¾ diameters each in the barrel."
3. Barrel 3ft., 17 gauge, weight 2lb. 15oz., and nearly a cylinder till within three inches of the muzzle, which is opened a little; whole weight of gun, 5lb. 13oz.
4. Barrel 3ft., 15 gauge, weight 3lb. 3oz., whole gun 6lb. 6oz.
5. Barrel 3ft. 2in., 15 gauge, weight 3lb. 12oz., whole gun 7lb. 3oz. "Two ounces of shot loaded it two diameters, and the same quantity in measure of powder."

6, 7, 8, 9, 10. Length of barrels, 3ft. 6in., 3ft. 3in., 3ft. 3in., 5ft., and 3ft. 8in. respectively, but size of bore not stated.

11. Real Spanish barrel 3ft. 2in., 14 gauge.
12. Barrel 4ft., 17 gauge. Also tried again after cutting off eight inches of the barrel. The average pattern at 40 yards was reduced from 71 to 45, and the author says: "Upon supposition that a gun loses half the quantity of shot every ten yards (and it appears from the experiments to be nearly so), this gun has lost about a yard in killing to one inch taken off from the length of barrel; but the difference of the force with which the shot were thrown was scarcely distinguishable."
13, 14, 15. These three barrels were all said to be "Spanish fashion," and measured 3ft. 3in., 3ft. 6in., and 3ft. 6in. respectively, but nothing is said as to diameter of bore.

Let the reader imagine what would be the charges of powder and shot as stated in the above summary. Nowadays the ordinary proportions (as 3drs. and 1¼oz. in a 12-bore, or 2½drs. and 1oz. in a 20-bore) would be about one diameter of each. In No. 5 gun (a 15-bore with 2oz. of shot) the proportions are about double this; and in No. 2 gun they are nearly treble.

Seeing how immensely long were some of the Spanish barrels which were used by English sportsmen in olden days, it is evident that they must have given ample opportunity for a full development of the propulsive force of the powder gases; but it is very questionable whether they gave so much killing power as many people then imagined. We had an opportunity, about seven years ago, of carrying out some experiments with a very extraordinary gun, which was English in its make, with the latest breechloading improvements, but built on Spanish lines, so far as the length of the barrels was concerned. It was made specially to order, by Mr Charles Lancaster, to meet the wishes of a sportsman resident in South America, and, although a 12-bore, had barrels which were 45in. long; but this enormous length gave practically very little advantage as regards velocity. The increase of length, as compared with 30in barrels, was 50 per cent., whereas the increase of velocity, with one nitro powder, was a fraction of 1 per cent., and with the other it was nearly 2 per cent.; but Colonel Hawker's opinion relative to the diminution of recoil was borne out by the results, as in the 45in. barrel one nitro gave 10 per cent. and the other 11 per cent. less recoil than it did in the 30in. barrel (after allowing for the difference in weight of the two guns). With black powder, however, the results were not the same; the fine-grain (No. 2) gave an increase of velocity in the 45in. barrel as compared with the 30in. barrel, while the coarse grain did so in a minor degree; but both showed less recoil than was proportionate to the speed of the shot. The difference in behaviour of the two classes of powder we attribute to the difference in their chemical composition. When the black powders are consumed, they leave an immense amount of solid residue, the intense heat of which tends to keep up an expansion of the gases throughout the longest barrels; but the nitro powders have very little solid residue, so that the expansion of the gases is not kept up to the same extent; consequently there is a tendency of the shot-charge to fall off in speed, owing to the friction of the pellets in the barrel; and the friction at the same time acts like a "brake" in retarding the backward motion of the barrel, and thereby lessening the amount of recoil.

Within the last ten years we have carried out a number of experiments with guns differing considerably in the dimensions of their barrels, for the purpose of obtaining definite information in reply to oft-repeated questions relative to the best length or best size of bore; and the results obtained have served to demonstrate that no hard-and-fast line can be laid down as to what is "best," so much being dependent upon variation of circumstances. It often happens, for instance, that the same gun will give very different results if a change is made in the powder, or the size of the shot, or in the proportions of the charge. Besides which there is the "personal equation" of the user of the gun; and some men find it impossible to shoot satisfactorily with barrels of a length which others consider to be the acme of perfection. No doubt a skilful gunmaker, if he knows the actual requirements of a customer, can make barrels of almost any length or gauge that will throw the shot well, so long as the owner of the gun keeps to the powder and other conditions for which the barrels were regulated; but a change in the charge, or the method of loading, may be more or less disconcerting in its results, according to the nature of the alteration.

In August 1889 we published detailed particulars of a trial of 12-bore barrels which were gradually reduced in length from 30in. to 22in. They were tested with seven kinds of powder (three of them being nitro-compounds), and the patterns at 40 yards were recorded, together with the penetration as taken by Mr Walsh's force-gauge. The barrels, both choke and cylinder, were regulated anew after each reduction in length, and gave in certain respects nearly the same average results as at first; but the shorter the barrels were made, the more irregular became some of the individual rounds, especially with the cylinder barrel, and with certain powders to a greater extent than with others; but as a number of "wild shots," which made no record whatever of penetration on the 10-inch plate of the force-gauge, were not included in the calculation of averages, the summary of results, when regarded alone, is apt to mislead, as the figures, if quoted without the explanatory context, make it appear as though the shortest barrels gave better results than they did in reality.

We afterwards repeated the experiments, with the same seven powders, in a 12-gauge gun, but with spherical ball fired from a barrel that was perfectly cylindrical in bore, and which consequently could be shortened from stage to stage without any internal alteration; while the velocities of the bullets were taken by chronograph from the muzzle of the gun, instead of the penetration of charges of small shot being estimated by force-gauge after they had traversed a distance of 40 yards. The records taken with spherical ball showed that there was considerable falling off in the speed of the projectiles on the barrel being reduced in length, and that this was more noticeable with nitros than with black powders.

These somewhat contradictory results, however, were more conflicting in appearance than in actuality, and were mainly attributable to the difference in the system of taking the records. When a single projectile is fired, whether it be a spherical ball or an elongated bullet, a knowledge of its weight, diameter, and muzzle velocity will enable an expert to calculate its actual speed at 40 yards or other given distance. But a similar calculation cannot be made with charges of small shot, as their velocity at a given distance depends, not merely upon the speed with which they were propelled from the muzzle of the gun, but upon the degree of compactness maintained by the mass of pellets during their passage through the air. The chronographic records taken from the muzzle show the velocities exhibited when the projectiles are at their highest rate of speed; whereas the records at 40 yards show the remaining penetrative force of pellets which usually have lost about one half of their original velocity—the amount varying more or less with the spread of the charge and the size of the shot. Hence a gun that is suitably bored, and used with a comparatively small quantity of powder, and consequently having a low muzzle velocity, may possible show as much or more penetration in a paper pad or cardboard rack, or higher record on the force gauge, than a less carefully-bored weapon using a larger quantity of powder, which expels a similar charge of shot with much higher speed, but scatters its pellets broadcast, and thus exposes them to greater atmospheric resistance, and consequent loss of velocity.

Marked instances of the difference between compact and scattered charges may often be seen when guns are given to "balling." We were experimenting with such a gun some years ago, using small charges of quick-burning powder and heavy charges of shot (as employed by our ancestors early in the present century), and it was found by chronograph that the mean velocity for 40 yards was barely 700 ft.sec. when the pellets spread properly, but was nearly 900 f.s. when the shot balled; and yet it is probable that the balled and the unballed charges left the muzzle of the gun with about the same initial rate of speed, whereas the difference in compactness of the two masses of pellets made all the difference in the amount of atmospheric

resistance which they respectively encountered, and the consequent degree of energy which they retained at the end of 40 yards.

In August 1891, when our new recoil machine had been constructed, we carried out a new series of experiments, in which the gunbarrel was of 12-gauge, 34in. in length, and bored perfectly cylindrical, so that it could be shortened to any extent without requiring regulation. It was gradually reduced down to 10in., and tested with seven kinds of powder and 1⅛oz. of No. 6 shot, while records of recoil were taken simultaneously with chronographic velocities. The results conclusively demonstrated, to our mind, that the amount of recoil bears no fixed relation to the speed and weight of the shot, as had generally been asserted, but that it varies considerably with the length of barrel, the nature and weight of the powder employed, and, in a minor degree, with the condition of the atmosphere at the time of the explosion. The following brief summary will show the falling off in velocity with the respective powders, as the 12-bore barrel was reduced in length from 34in. to 18in. The charge of shot was 1⅛oz. throughout; of the black and brown powders an equal weight (3drs.) was here used with all, although the makers recommend a difference of weight according to

12-BORE GUN (ORIGINAL WEIGHT, 7LB.), WITH 26GRS. OF CONCENTRATED NITRO POWDER.

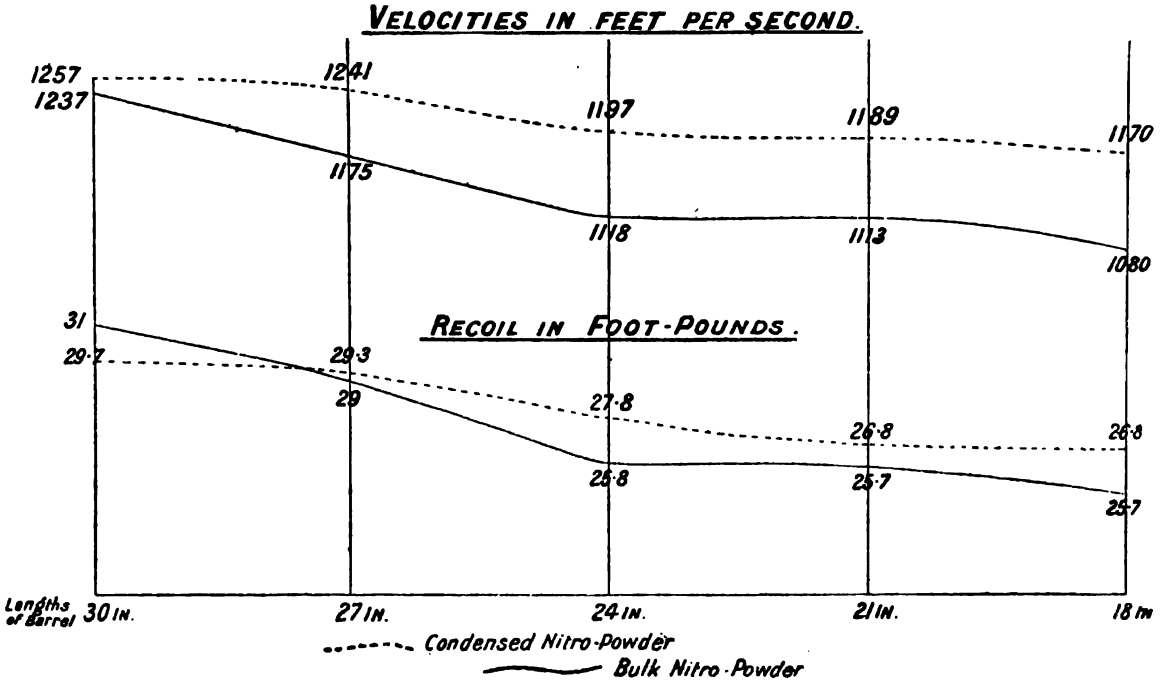
(Barometer, 29·80in.; Thermometer—Dry 70°, Wet 65°.)

30IN. BARREL.		27IN. BARREL.		24IN. BARREL.		21IN. BARREL.		18IN. BARREL.	
Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.
1277	31·0	1277	30·2	1220	28·3	1220	28·3	1205	28·2
1271	30·6	1260	30·4	1210	27·9	1200	27·6	1205	28·2
1266	29·5	1255	30·2	1205	28·2	1200	26·6	1186	27·5
1260	29·3	1255	28·9	1205	28·0	1190	27·3	1181	27·0
1255	30·4	1240	29·4	1200	28·0	1186	27·1	1167	26·7
1255	29·5	1235	28·6	1195	28·0	1181	26·1	1158	26·6
1250	29·4	1230	29·7	1190	27·3	1181	26·0	1154	26·2
1250	29·3	1225	28·3	1186	27·6	1176	27·2	1149	26·8
1245	29·0	1220	28·1	1181	27·1	1176	26·0	1149	25·2
1240	29·4	1215	29·5	1176	27·2	1176	26·0	1141	25·2
1257	29·7	1241	29·3	1197	27·8	1189	26·8	1170	26·8
Average of 10.		Average of 10.		Average of 10.		Average of 10.		Average of 10.	

12-BORE GUN, WITH 42GRS. OF BULK NITRO POWDER.

(Barometer, 29·80in.; Thermometer—Dry 70°, Wet 65°.)

30IN. BARREL.		27IN. BARREL.		24IN. BARREL.		21IN. BARREL.		18IN. BARREL.	
Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.
1277	32·0	1205	30·0	1158	27·5	1145	27·0	1132	26·9
1277	31·7	1200	30·2	1154	26·8	1132	26·6	1128	27·7
1277	31·0	1200	29·7	1145	26·0	1128	26·5	1124	26·2
1255	31·4	1186	29·0	1132	26·0	1119	26·1	1111	25·6
1240	31·3	1181	29·3	1128	25·7	1115	25·8	1095	25·4
1230	30·8	1172	29·1	1115	27·2	1103	25·5	1075	24·8
1220	31·7	1163	28·9	1107	24·9	1103	25·0	1064	25·0
1210	29·7	1158	28·8	1095	24·1	1099	24·9	1049	24·7
1200	30·0	1158	28·0	1083	24·5	1091	25·6	1024	22·8
1186	30·4	1128	26·8	1064	23·4	1091	23·6	1000	22·0
1237	31·0	1175	29·0	1118	25·8	1113	25·7	1080	25.1
Average of 10.		Average of 10.		Average of 10.		Average of 10.		Average of 10.	



the nature of the powder. In like manner, with the nitro powders, equal charges (42grs.) were used of all, although the charge of S.S. is ordinarily a grain less than the other two. The results were as follows:

VELOCITIES.

	34in.	30in.	26in.	22in.	18in.
No. 2 Black	1147	1122	1115	1075	965
No. 4 ,,	1122	1114	1089	1051	963
No. 6 ,,	1094	1051	935	910	876
Brown	1102	1022	1034	929	811
Schultze	1119	1113	1075	988	1007
E.C.	1120	1106	1033	964	982
S.S.	1162	1110	1016	991	1016

Since the above-mentioned experiments were carried out, we have very seldom had recourse to the use of either paper pads or the force-gauge as a test of penetration. We consider it better to adopt a standard velocity as a general basis of comparison; and then it is comparatively easy to ascertain what quantity of powder (whether of an old black mixture or a new chemical compound) is required to impart a corresponding velocity to the shot as it leaves the muzzle of the gun; and, when this has been done, the relation which the amount of recoil and the stress in the barrel bear to the velocity of the shot also becomes apparent. These particulars relate to matters of general principle, and are of importance in their application to powders as a whole, whereas the patterns of the guns may be considered rather as matters of detail, which are mainly of interest to the owners of the individual weapons. And, although we usually print records of pattern, taken simultaneously with the velocity and recoil, their value is subsidiary; for, however excellent a powder may be in itself, the quality of the gun's performance at the target may be made or marred by the skilfulness or otherwise of the borer of the barrel, or the carefulness or carelessness exhibited in the making or loading of the cartridges.

In the experiments recently carried out, we have not limited the trials to guns of 12-bore, but have adopted three widely distinctive gauges, for the reasons explained in our article of Aug. 27. The results then published were obtained with No. 4 black powder exclusively; now we give the records taken with two different kinds of nitro powders, one of which is of the so-called "bulk" class—that is to say, using a charge which is equal in bulk to that ordinarily used for black powder—while the other is of the "condensed" class, and employs a charge which is much smaller by measure as well as in weight. We have not thought it desirable to test all the nitro powders of both classes, as previous experiments have shown that, where many specimens are tried, there are various small points of difference, which occasionally overlap one another, and so tend to produce confusion. Accordingly we have limited our present trial to the oldest of the bulk powders (viz., Schultze), and the most condensed of the nitro-compounds made in this country for use in shot guns (viz., Ballistite); the charge of the bulk powder ordinarily taken to represent the equivalent of 3drs. of black powder is 42grs. (or about 1½drs.), whereas the corresponding equivalent of the condensed powder here used is but 26grs. The bulk powder was loaded in the ordinary flat-based cartridges made by Messrs Eley, while the condensed powder was loaded in the special cone-based cases of the same makers.

The results obtained by firing ten rounds of each kind of explosive with 1⅛oz. of No. 6 shot, in a 12-gauge cylindrical barrel, gradually shortened from 30 to 18 inches (but with no touching up or regulation of the boring), will be found fully set forth in the accompanying large tables. We may add, however, that the length of the barrel was measured, not from the breech end of the cartridge, but from the top wad, as otherwise the reduction in length would not be in regular proportion. We have arranged the record in numerical order, for facility of comparison; the velocity and recoil were taken simultaneously from the same round. We add a brief summary of the velocities with the respective lengths of barrel from 30in. down to 18in., for comparison with those obtained in the trial of seven years ago:

Velocity.	30in.	27in.	24in.	21in.	18in.
Concentrated	1257	1241	1197	1189	1170
Bulk	1237	1175	1118	1113	1080

It will here be seen that the velocity of the shot from the 18in. barrel was much higher than in the 1871 trials; and from the accompanying diagram of curves it will be seen how the amount of recoil varies with the two powders. But we must defer comment to the next article, when we propose to give the results obtained, under similar circumstances, with a 20-bore gun.

(*Field*, Oct. 1, 1898; Vol. 92, p. 558.)

In the previous article we furnished some particulars of a trial of concentrated and bulk nitro powders in a 12-bore gun, the barrel of which was gradually shortened from 30in. down to 18in., by cutting off, at each reduction, one-tenth of its original length. We did not attempt, by varying the charge, to obtain any definite muzzle velocity with the 30in. barrels, but with each explosive we adopted the ordinary charge prescribed by the respective makers, viz., 26grs. of the concentrated and 42grs. of the bulk powder, with 1⅛oz. of No. 6 shot. The concentrated powder was loaded in cone-base cases, and the bulk powder in flat-base cases by the same makers.

Now we lay before our readers a similar diagram and tables relative to experiments of a like character carried out with a 20-bore; and for the sake of comparison we will here briefly summarise the results obtained with the two guns. The charge used with the 20-bore was 22grs. of concentrated or 35grs. of bulk powder, and 1oz. of No. 6 shot. The wads with the 12-bore were, first, a thin card, then ½in. felt and grey cloth wad, and a thin card over the shot. With the smaller gauge the wads were similar, except that, instead of the grey cloth over the shot, a stout card had to be substituted, in order to secure a satisfactory amount of turnover. The average velocities of ten rounds, with each of the five lengths of barrel, were as follows:

Concentrated Powder Velocities, in feet per second.

	30in.	27in.	24in.	21in.	18in.
12-bore	1257	1241	1197	1189	1170
20-bore	1224	1192	1176	1161	1158
Differences	−33	−49	−21	−28	−12

Bulk Powder Velocities, in feet per second.

	30in.	27in.	24in.	21in.	18in.
12-bore	1237	1175	1118	1113	1080
20-bore	1191	1165	1151	1149	1118
Differences	−46	−10	+33	+36	+38

It is rather curious that, whereas there was some little reduction of velocity with the concentrated powder in the 20-bore at every stage of the shortened barrel, yet with the bulk powder there was a reduction at the first two lengths only, while at the other three there was an increase.

Many writers have suggested that the length of barrels should bear a definite proportion to the diameter of the bore. The author of the old book on "The Art of Shooting Flying," from which we gave some extracts in the previous article, says with respect to dimensions of barrels: "Pieces of any sized bores must have so many diameters in length, and the same proportion of powder to the size of ball, to give the same velocities." In his early editions Mr Page recommended to his readers the study of the writings of Benjamin Robins, the celebrated mathematician and author of the "New Principles of Gunnery," published in the first half of the last century; and in his seventh edition Page gives abstracts from Robins's work, with particulars as to how to make the calculations. More than half a century later we find Colonel Hawker writing of a 14-gauge gun as having "2ft. 8in. barrels, or 44 diameters," and he pronounces in favour of 3ft. barrels, the length of which would be about six diameters more. And in an article in the *Field* of Nov. 12, 1892, giving the results of very extensive experiments with guns and powders carried out on behalf of the French Government, the writer says: "The conclusion that one arrives at from these and other experiments, is that the total length of barrel in a shot gun should be from 40 to 45 calibres, to obtain the most useful effect."

Now, 40 calibres of 12-gauge are equal to rather over 29in., while 45 amount to rather less than 33in.; so that this estimate accords pretty closely with the general practice of those who adopt 30in. barrels. But if that length be suitable for 12-bore guns, it by no means follows that it is equally suitable for guns of different gauge; and yet many people think it necessary to have barrels of equal length, no matter what may be the size of the bore. Of course, if they find that a change in length of the barrels throws them off their shooting, they are quite right in adhering to that kind of gun which gives them the best results. But 30in. barrels are not requisite with small-bores, to secure a proper combustion of the powder, more especially with the modern explosives.

In our present experiments, to test the effects of shortening the barrels of guns employed with the modern "concentrated" and "bulk" nitro powders, we have used much shorter tubes than those alluded to above; and it may be of interest to our readers if we give a table showing how many calibres or diameters of bore there are in

barrels of the three gauges used in these experiments, besides those of several other bores in common use nowadays:

DIAMETERS OF BORE IN LENGTH OF BARREL.

	30in.	27in.	24in.	21in.	18in.
12-bore (·729 inch)	41	37	33	29	25
16-bore (·662)	45	41	36	32	27
20-bore (·615)	49	44	39	34	29
24-bore (·579)	52	47	42	36	31
28-bore (·550)	54	49	44	38	33

Thus it may be seen that a 30in. 12-bore, a 27in. 16-bore, a 25in 20-bore, and a 22in. 28-bore, would all stand upon nearly equal terms as to the number of their diameters.

We receive, from time to time, questions asking how the various bores obtained their names and dimensions; and we may therefore explain, for the information of those not already acquainted with the fact, that the names were derived from the weight of the largest spherical lead bullets which, in the old muzzle-loading days, could be employed in the respective barrels; while the dimensions of the bullets are stated to the thousandth part of an inch in modern Acts of Parliament that relate to the proof of guns, and the schedules framed for their amendment. Thus, 12-bore barrels of ·729in. gauge would admit bullets of 12 to the pound, *i.e.*, weighing rather over 1¼oz.; a

20-BORE GUN (WEIGHT 6LB.), WITH 22GRS. OF CONCENTRATED NITRO POWDER.

(Barometer, 30·00in.; Thermometer—Dry 77°, Wet 73°.)

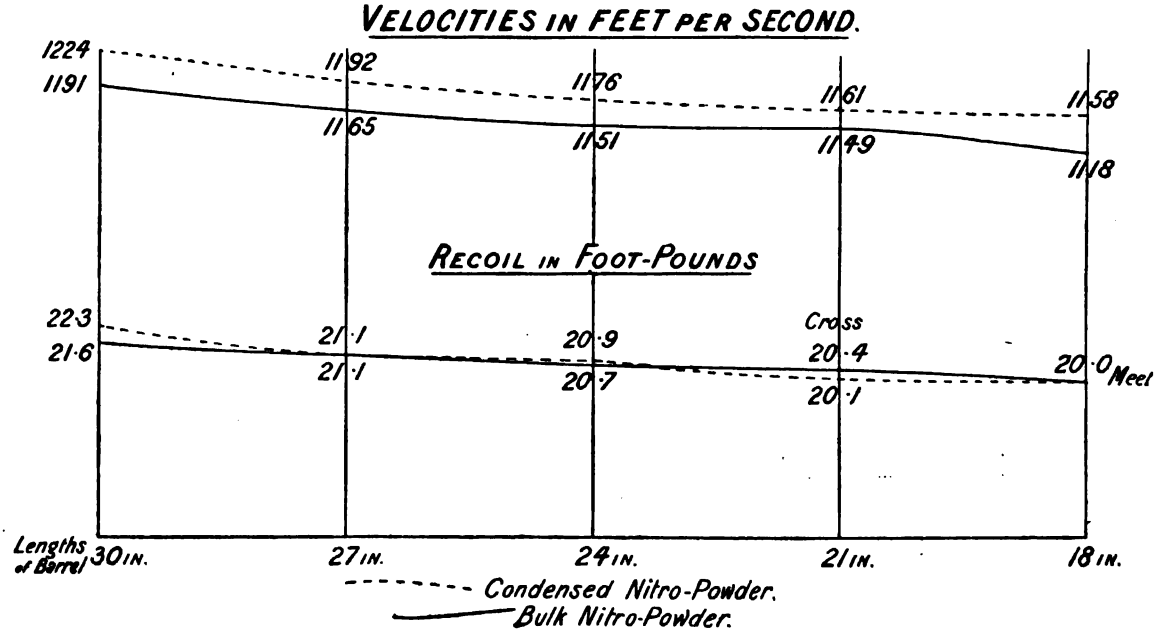
30IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	27IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	24IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	21IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	18IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.
1250	22·7	1250	23·0	1250	22·5	1230	22·0	1210	22·0
1245	22·4	1230	21·3	1220	21·8	1205	21·0	1205	22·0
1240	23·0	1225	22·0	1200	22·0	1181	21·2	1167	20·2
1235	23·1	1220	21·8	1195	21·6	1163	20·7	1163	20·0
1235	22·8	1190	21·1	1172	21·0	1149	19·6	1154	20·4
1225	22·2	1172	20·5	1163	21·4	1149	18·9	1149	19·8
1215	22·5	1167	20·6	1158	20·3	1141	19·0	1141	19·7
1210	21·8	1163	19·5	1141	20·0	1136	20·0	1136	18·6
1200	22·0	1158	19·2	1136	19·6	1136	19·6	1132	18·6
1190	20·5	1145	22·4	1132	19·3	1124	18·8	1128	18·5
1224	22·3	1192	21·1	1177	20·9	1161	20·1	1158	20·0
Average of 10.		Average of 10.		Average of 10.		Average of 10.		Average of 10.	

20-BORE GUN (WEIGHT 6LB.), WITH 35GRS. OF BULK NITRO POWDER.

(Barometer, 30.00in.; Thermometer—Dry 77°, Wet 73°.)

30IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	27IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	24IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	21IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.	18IN. BARREL. Velocity. Ft.sec.	Recoil. Ft.lb.
1216	22·1	1195	22·0	1200	22·2	1190	21·8	1149	21·0
1215	22·0	1190	21·7	1176	21·8	1176	21·3	1136	21·0
1210	21·8	1181	21·5	1158	21·5	1172	21·2	1132	20·4
1205	22·1	1176	21·3	1154	20·6	1167	21·5	1128	21·0
1195	21·5	1172	21·2	1145	19·8	1158	21·4	1124	20·1
1190	22·5	1163	21·0	1141	20·5	1141	20·0	1115	20·3
1186	21·4	1163	20·8	1141	19·6	1132	19·4	1115	20·0
1181	21·7	1158	20·9	1136	20·9	1128	20·1	1107	18·5
1172	21·2	1128	20·5	1132	20·0	1124	19·0	1091	19·2
1141	20·0	1128	20·0	1123	19·9	1107	18·0	1083	18·7
1191	21·6	1165	21·1	1151	20·7	1149	20·4	1118	20·0
Average of 10.		Average of 10.		Average of 10.		Average of 10.		Average of 10.	

20-BORE GUN.



16-bore gun of ·662in. gauge would take bullets of 16 to the pound, or 1oz., and so on; but nowadays there are frequent fractional variations in different guns, and many so called 12-bores bear proof-marks showing that they were proved as guns of 13-gauge, while similar differences occur in other bores.

We may add that the schedules also contain the "service charges" of powder and shot for the various bores; and the weight of the shot charges prescribed is near about the weight of the spherical ball for the corresponding bore, while the black powder charge is about one-sixth the weight of the shot. Thus, in the case of the commonly used charge of 3drs. and 1¼oz., the shot is exactly six times the weight of the powder—1½oz. being equivalent to 18 drams. In the Proof Acts, however, 3drs. and 1⅛oz. is not the "service charge" for the 12-bore, but for 14-bores. Strictly speaking, however, there is no legal limit as to the quantity of powder and shot that a sportsman may put into his gun; the above weights are merely used as a basis whereon to estimate the amount of the proof-charge, and if the owner of the gun chooses to overload or underload after it has been proved, he is quite at liberty to do so.

If, however, these "service charges" were adhered to, the length of the cylindrical body of shot in the barrel, and of the corresponding mass of powder, would each closely approximate to the diameter of the bore; and in such cases the method of calculating by calibres might very well be put into operation; but if owners of guns use other proportions of powder and shot, it must be obvious that reckoning by diameter of bore alone would not produce satisfactory results.

A method which we consider preferable to estimating by the number of calibres or diameters would be to estimate by the number of expansions of gas in the barrel, were sufficient data available.

If the "service charge" of guns were in ordinary use by sportsmen – or, in other words, if the length of the powder charge were usually equal to its diameter—then the number of calibres would be practically synonymous with the number of gas expansions in the barrel, so far as black powder is concerned, and also, perhaps, with regard to the bulk nitro powders; but with the concentrated powders there would be some difficulty in making any definite estimate. For instance, with the concentrated powder used in our present experiments 26grs. are adopted by the makers as the equivalent of 3drs. of black, whereas with another variety 30grs. are used, with another 33grs., and so on. And, indeed, something of the same kind occurs also with black powders, their charges being varied according to the size and density of the grain, though not to the same extent as with nitros.

In a most exhaustive paper contributed to the "Philosophical Transactions of the Royal Society" some twenty years ago, Capt. Noble and Professor Abel (now Sir F. Abel and Sir A. Noble) described the results of experiments which they had carried out with black gunpowders, and we quote from the second volume of Mr Walsh's work on "The Modern Sportsman's Gun and Rifle" a few particulars relating thereto:

It would occupy too much space here to give the full details leading up to Messrs Noble and Abel's conclusions, but it may be stated briefly that they are based on the fact that, if the powder be turned into gas before the projectile has moved from its position, the gas will expand a certain number of times before the shot leaves the muzzle—the number of volumes of expansion depending upon the proportion of space occupied by the powder-charge as compared with the total amount of space in the barrel. They have accordingly prepared a table which sets forth the number of foot-tons of work which each pound of powder is capable of producing according to the volumes of expansion that occur in the gun. Of course it is necessary to know the diameter and length of the bore in order to ascertain the amount of space contained therein; and it is also necessary to know the amount of that space which is occupied by the powder. Pounds of powder and foot-tons of energy are far too grand in scale to serve as units for purposes of calculation in what concerns sporting arms. Accordingly, it has been found necessary to turn them into drams of powder and foot-pounds of energy. With this amount of alteration, the following short table will afford some notion of the longer table contained in the "Philosophical Transactions," except that it omits the fractional parts of volumes of expansion and the density of products of combustion.

Number of Volumes of Expansion.	Total work that one dram of gunpowder is capable of performing.	Number of Volumes of Expansion.	Total work that one dram of gunpowder is capable of performing.	Number of Volumes of Expansion.	Total work that one dram of gunpowder is capable of performing.
Volumes.	Foot-pounds.	Volumes.	Foot-pounds.	Volumes.	Foot-pounds.
1	.....	11	1060	21	1253
2	492	12	1087	22	1267
3	607	13	1112	23	1280
4	718	14	1134	24	1292
5	800	15	1155	25	1303
6	863	16	1174	26	1315
7	915	17	1192	27	1326
8	959	18	1209	28	1336
9	997	19	1225	29	1345
10	1030	20	1239	30	1354

It will be observed, in the first line of the table, that no figures occur opposite to the volume of expansion; the reason is that nothing has been done. When the powder is shut up and fired, and the gas occupies only the same amount of space as the unfired powder, no work has been effected; when the force of the gas enlarges the space occupied, work has been done, but the amount would vary according to the resistance that has been overcome. The maximum amount of work which could be done by one dram of powder, in doubling the space occupied, would be 492 ft.lb.; the maximum in three times that space would be 607 ft.lb., and so on. Every additional expansion increases the amount of work done, but the rate of increase diminishes continuously, as the tension of the gas decreases. Thus, if one gunbarrel is of such a length that 3drs. of powder occupy one-tenth of the bore, and another is of such length that 3drs. occupy only one-twelfth of the bore, the latter would have 12 expansions to 10 of the former. The total capacity for work in the one case would therefore be 3 (drs.) multiplied by 1030 ft.lb., and in the other it would be 3 multiplied by 1087 ft.lb.; consequently the same charge of powder would, in the one barrel, be able to do 151 ft.lb. more work than it could do in the other.

The above particulars relate to black gunpowder, and we are not aware of any similar data being available with respect to more modern sporting explosives; but an examination of the records with respect to our present experiments seems to show that any method of estimating solely by calibres could not be satisfactorily applied alike to concentrated nitro powders and to those of the bulk class. For example, supposing that the mode of estimation above set forth with respect to the black explosive were also applicable to the bulk nitro powders, it would not apply to the concentrated class without some modification. If we were to assume that the two explosives are of the same specific gravity, the bulk powder with 42grs. would occupy 60 per cent. more space than the concentrated powder with 26grs.; consequently, if there were forty expansions of gas in the 30in. barrel with the bulk powder there would be more than sixty expansions with the concentrated. Is it not probable that this difference of expansion has something to do with the concentrated powder showing less falling off in velocity when the barrels are reduced in length?

(*Field*, Oct. 15, 1898: Vol. 92, p. 645.)

THE particulars published in the preceding article showed some rather curious differences in the behaviour of the concentrated and the bulk nitro powders as the barrels of the 12-bore and 20-bore guns were gradually shortened. The concentrated variety exhibited a decrease in velocity at all the five lengths of barrel with both gauges; whereas the bulk powder gave a reduction of speed in the 20-bore, in comparison with the 12, at the first two stages only, after which the 20-bore exhibited greater velocity than the 12-bore throughout the remaining three stages (viz., 24in., 21in., and 18in.), and the difference increased stage by stage, as will be seen by the figures given in the next table.

Now we have in print the full records of the 28-bore; and it will be observed, from the accompanying summary, that the differences between the 20 and the 28 are all in the way of diminution with the concentrated powder, although the decrease is trifling, except in the final stage. On the other hand, with the bulk powder, the 28-bore shows a small excess over the 20 in three stages out of the five, with a little decrease in the remaining two, as will be seen by reference to the following table, where the increase and decrease are shown by the *plus* (+) and *minus* (–) signs:

CONCENTRATED POWDER VELOCITIES, in feet per second, with reductions in length of barrel.

Charges.	30in.	27in.	24in.	21in.	18in.
12-BORE.....	1257	1241	1197	1189	1170
(26grs. and 1⅛oz.)	−33	−49	−21	−28	−12
20-BORE.....	1224	1192	1176	1161	1158
(22grs. and ⅞oz.)	−14	− 6	− 5	− 8	−25
28-BORE.....	1210	1186	1171	1153	1133
(18grs. and ¾oz.)					

BULK NITRO POWDER VELOCITIES, in feet per second, with reductions in length of barrel

Charges.	30in.	27in.	24in.	21in.	18in.
12-BORE.....	1237	1175	1118	1113	1080
(42grs. and 1½oz.)	−46	−10	+33	+36	+38
20-BORE.....	1191	1165	1151	1149	1118
(35grs. and ⅞oz.)	+ 7	+ 3	+ 4	− 7	− 4
28-BORE.....	1198	1168	1155	1142	1114
(28grs. and ¾oz.)					

We had long been of opinion that the dimensions of the bore have a considerable influence upon the effects produced by different explosives and various sizes of shot, owing to the different amount of friction in the respective barrels, and the influence which such frictional resistance has in developing the explosive force of the

powder gases. The amount of force exhibited is, so to speak, not a fixed quantity dependent upon the amount of powder that is used, but may rather be said to be a very indefinite quantity, varying with the amount of resistance that is encountered at the time of ignition. Thus, 3drs. of black powder, with 1¼oz. of No. 6 shot, in a 12-bore gun, will give a pressure of from two to three tons per square inch, varying more or less with the size of grain of the powder—the finer the grain the greater being the amount of stress in the chamber of the same kind of powder may be said to have developed in the one case about fifteen times as much energy as it did in the other. It has been shown, too, that the full amount of stress which may be developed by black powder reaches about 42 tons per square inch; and it is said that some of the nitro-compounds are capable of considerably exceeding that vast amount of force.

To return, however, from these huge pressures to the moderate amounts of stress in sporting guns, it may readily be understood that,

28-BORE GUN (WEIGHT 5LB.), WITH 16GRS. OF CONCENTRATED NITRO POWDER AND ¾OZ. No. 6 SHOT.

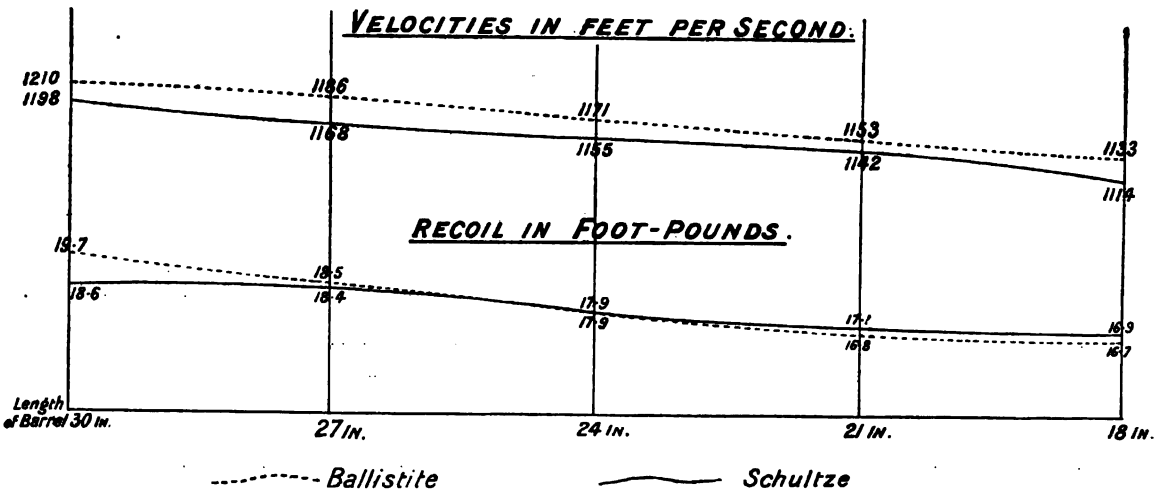
(Barometer, 29·81in.; Thermometer—Dry 68°, Wet 62°.)

30IN. BARREL.		27IN. BARREL.		24IN. BARREL.		21IN. BARREL.		18IN. BARREL.	
Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.
1250	21·0	1225	19·3	1200	19·4	1172	17·6	1158	17·5
1240	20·6	1215	19·0	1186	18·4	1167	17·4	1154	17·3
1235	20·7	1200	19·1	1181	18·8	1163	17·2	1145	17·0
1230	20·5	1195	18·8	1176	18·0	1158	17·0	1136	16·8
1230	20·5	1100	18·7	1172	18·0	1154	16·9	1132	16·7
1225	19·8	1181	18·5	1172	17·5	1154	16·8	1128	16·8
1205	19·4	1176	18·4	1163	17·9	1149	16·7	1124	16·6
1200	19·5	1176	18·3	1158	17·2	1141	16·1	1124	16·4
1145	17·8	1149	17·6	1158	17·0	1141	16·0	1119	16·3
1141	17·6	1149	17·4	1145	16·8	1132	15·9	1115	16·0
1210	19·7	1186	18·5	1171	17·9	1153	16·8	1133	16·7
Average of 10.		Average of 10.		Average of 10.		Average of 10.		Average of 10.	

28-BORE GUN (WEIGHT 5LB.), WITH 35GRS. OF BULK NITRO POWDER AND ¾OZ. No. 6 SHOT.

(Barometer, 29·81in.; Thermometer—Dry 68°, Wet 62°.)

30IN. BARREL.		27IN. BARREL.		24IN. BARREL.		21IN. BARREL.		18IN. BARREL.	
Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.	Velocity. Ft.sec.	Recoil. Ft.lb.
1220	19·2	1195	19·0	1172	18·6	1158	18·2	1136	17·7
1215	18·8	1190	18·8	167	18·8	1158	18·0	1132	17·5
1210	18·9	1181	18·9	1163	18·3	1154	17·6	1128	17·0
1210	18·6	1172	18·4	1163	18·0	1149	16·8	1124	17·0
1205	19·0	1167	18·4	1158	17·8	1145	17·8	1119	17·2
1205	18·5	1163	18·3	1154	17·5	1145	17·4	1115	16·6
1200	18·8	1158	18·0	1149	18·0	1136	16·9	1107	17·1
1186	18·7	1154	18·2	1149	17·4	1132	16·2	1095	16·8
1186	17·9	1154	18·0	1141	17·3	1124	16·0	1095	16·4
1141	17·6	1149	17·5	1136	17·0	1119	16·2	1087	16·1
1198	18·6	1168	18·4	1155	17·9	1142	17·1	1114	16·9
Average of 10.		Average of 10.		Average of 10.		Average of 10.		Average of 10.	



the gun. But if only 30grs. (or little more than one dram of black powder) were used in so small a bore as the ·303 rifle (as was the case before the black powder was superseded by Cordite), the pressure in that narrow gauge, with the resistance of the long projectile in the rifled barrel, would be raised to about 15 tons per square inch. So there we find an example of little more than a single dram of powder producing a stress about five times as great as 3drs. of the same explosive in another barrel; thus relatively, in these two instances, if one increases the resistance in a smoothbore barrel by the use of a larger quantity of shot, or by employing an equal weight of smaller pellets, or the same charge of shot in barrels of narrower gauge, an increase of friction will ensue, and a larger amount of force be developed from the powder.

Having taken such matters into consideration, we commenced the present series of experiments by endeavouring to obtain some definite notion of the effects of friction in the barrel. For this purpose we

took three guns, of three different gauges, and first tested them with steel bullets—one of 1¼oz. for the 12-bore; two, weighing 1oz. and ⅞oz. respectively, for the 20-bore; and two, ⅞oz. and ¾oz. for the 28-bore. Full details of these experiments were published in the *Field* of Aug. 27, 1898, but we shall here summarise only such particulars as relate to projectiles of one weight in each bore—*i.e.*, the same weight as the shot-charge subsequently employed with the shortened barrels of these three gauges, and with the two varieties of nitro powders mentioned above.

The steel bullets alluded to were practically frictionless, as each of them was an easy sliding fit in its bore and was also slightly greased; so that any friction in the barrel could only proceed from the wads. The charges of powder (No. 4 black) were carefully regulated so as to give as nearly as possible the same average velocity (viz., 1160 ft.sec. in a range of 10 yards); and when the experiments with the frictionless bullets had been completed, the powder was increased just enough to overcome the friction of a corresponding charge of No. 4 shot, and produce a similar velocity. This having been done, a further increase of powder was employed to overcome the larger amount of friction produced by the pellets of No. 6; and after that a similar process was carried out to meet the additional friction with No. 8 shot. In the following table we give the weights of the respective charges of powder, and the per-centages of increase; from which it will be seen that, with the 1¼oz. projectiles in the 12-bore, 9 per cent. more powder was required with No. 4 shot, 11 per cent. with No. 6, and 15 per cent. with No. 8, in order to produce velocity equal to that of the bullet. And the subsequent lines will show what were the corresponding additions to the amount of stress in the chamber of the gun, as well as the corresponding increase of recoil. These are the average results obtained by firing ten rounds of each of the cartridges used in the three bores:

VARIATIONS OF PER-CENTAGE WITH BLACK POWDER AND DIFFERENT SIZES OF SHOT, IN 12, 20, AND 28-BORE GUNS.

12-BORE AND 1¼oz.	Bullet.	No. 4.	No. 6.	No. 8.
Powder charges	73grs.	80grs.	82grs.	84grs.
=per-centages	1·00	1·09	1·11	1·15
Pressures	1·00	1·02	1·05	1·06
Recoil	1·00	1·01	1·06	1·09
20-BORE AND ⅞oz.				
Powder charges	61grs.	69grs.	71grs.	74grs.
=per-centages	1·00	1·13	1·16	1·21
Pressures	1·00	1·12	1·23	1·34
Recoil	1·00	1·11	1·20	1·29
28-BORE AND ¾oz.				
Powder charges	46grs.	50grs.	53grs.	53grs.
= per-centages	1·00	1·09	1·15	1·15
Pressures	1·00	1·06	1·14	1·22
Recoil	1·00	1·06	1·12	1·14

With the diminution of bore, of course the charges of powder and shot were decreased; but it will be observed that the per-centages of the 20-bore were raised to a greater extent than in the 12, alike as regards the proportion of powder, the pressure in the barrel, and the recoil. With the 28-bore, however, the per-centage of powder was near about the same as in the 12; but the per-centages of increase in pressure and recoil were considerably higher than in the 12-bore, though not so high as in the 20. This increase may be attributed, more or less, to several different circumstances. In the first place there is the greater amount of friction consequent on diminution of bore, which leads to the development of greater force in the powder; and there is also increased detonative effect on the explosive used, owing to the lesser charges of powder fired in the small cartridges being acted upon by caps of the same size as those employed in cartridges of larger gauge. Hence, if one uses 50grs. of powder in the narrow bore, and 80grs. in that of wider gauge, the effect of the ignition upon the smaller charge of powder would be very similar to that of adding 60 per cent. to the quantity of fulminating composition used with the larger charge. Accordingly, the powder would be rendered additionally sensitive, so to speak, and any little excess or deficiency in the amount of detonating composition in individual caps would become intensified in the explosive results.

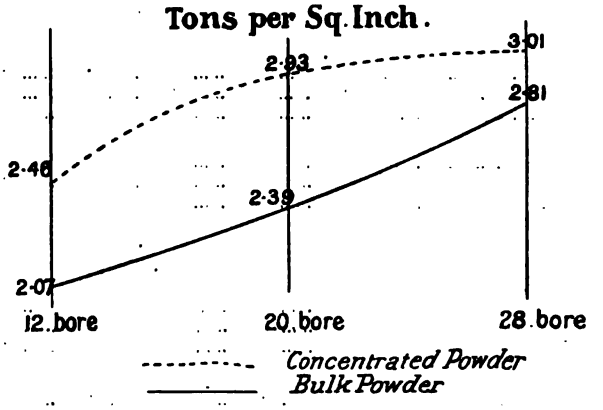
In the different bores, moreover, there are different degrees of variation in the amount of irregularity which occurred in successive charges fired from the respective guns with their allotted charges; but while there are some tolerable variations with both velocities and recoil, these are small in proportion to the variations in amount of pressure in the barrel, more especially in the 28-bore. Detailed particulars relative to the per-centages of variation between the highest and lowest rounds in each of the three bores, when No. 4 black powder was used, are given in the following table:

VARIATION IN VELOCITIES WITH NO. 4 BLACK POWDER.

	Bullet.	No. 4 shot.	No. 6 shot.	No 8 shot.
12-bore (1¼oz.)	2%	3%	2%	3%
20-bore (1oz.)	2%	2%	2%	2%
28-bore (⅞oz.)	4%	3%	3%	3%
VARIATION IN RECOIL.				
12-bore (1¼oz.)	3%	5%	4%	5%
20-bore (1oz.)	3%	3%	5%	3%
28-bore (⅞oz.)	5%	4%	6%	4%
VARIATION IN PRESSURE.				
12-bore (1¼oz.)	8%	14%	14%	15%
20-bore (1oz.)	8%	13%	10%	17%
28-bore (⅞oz.)	11%	29%	25%	10%

It will be observed that in this table we have represented the per-centages of variation in a fashion somewhat different from those previously given. This is owing to the fact that, in order to obtain a suitable basis of comparison, we had to take the average of each ten rounds as a special basis, then ascertain how much the highest round was in excess of this standard and how much the lowest was deficient. For instance, in one case the highest round might be 1 per cent. above the average and the lowest 1 per cent. short of it. If all had been thus equally balanced, there would have been no difficulty; but in another case the excess might be 5½ per cent. and the deficiency 2½, or *vice versa*; while in other cases the results might be still wider apart. To state all these individual variations would be very confusing; hence we give, in each instance, merely the sum of the two differences, as representing the total amount of variation.

When we came to the two kinds of nitro powders used in the shortened barrels of three gauges, we found other differences. The black powder trials were carried out with full length of barrel and several varieties of shot. In the next experiments, with nitro-compounds, there was no change in the size of shot (No. 6 being used throughout). Ten rounds of each powder were fired from the three bores, with the charges stated below; and it will be seen that, notwithstanding the reduction of powder and shot, the pressure increased with each diminution of gauge, as shown in the accompanying diagram of averages of the three bores:



The full particulars of the individual pressures of the six series of ten rounds each are given in the following table:

CRUSHER-GAUGE PRESSURES (in tons per square inch) with the three bores (12, 20, and 28), taken 1 inch from the breech, and arranged in order of pressures, highest first; ten rounds each.

	Tons.	Tons.	Tons.	Tons.	Tons. Averages.
12-BORE, with 1¼oz. No. 6 shot.					
Concentrated, 26grs.	2·82	2·76	2·64	2·55	2·43
	2·37	2·31	2·24	2·24	2·20 } 2·46 tons.
Bulk Powder, 42grs.	2·31	2·24	2·16	2·12	2·08
	2·04	2·00	1·96	1·92	1·88 } 2·07 tons.
20-BORE, with ⅞oz. No. 6 shot.					
Concentrated, 22grs.	3·06	3·02	3·00	2·97	2·94
	2·91	2·88	2·88	2·85	2·82 } 2·93 tons.
Bulk Powder, 35grs.	2·76	2·61	2·55	2·49	2·43
	2·37	2·28	2·24	2·20	2·00 } 2·39 tons.
28-BORE, with ¾oz. No. 6 shot.					
Concentrated, 18grs.	3·56	3·30	3·24	3·20	2·97
	2·91	2·88	2·76	2·70	2·61 } 3·01 tons.
Bulk Powder, 28grs.	3·16	3·06	3·06	2·85	2·79
	2·73	2·70	2·67	2·61	2·58 } 2·81 tons.

The variations of pressure of the above record, with the two varieties of explosives, are shown more briefly in the following summary, indicating the difference between the highest and lowest rounds of the respective series.

PER-CENTAGE OF VARIATIONS IN PRESSURE.

	12-Bore. (26grs. and 1⅛oz.)	20-Bore. (22grs. and ⅞oz.)	28-Bore. (18grs. and ¾oz.)
Concentrated Powder	25%	8%	31%
	(42grs. and 1½oz.)	(35grs. and ⅞oz.)	(28grs. and ¾oz.)
Bulk Powder	21%	32%	19%

We may here mention that equal charges were used throughout in the same gun, whatever may have been the length to which the barrels were reduced.

It seems rather strange that there should be so great a difference in the variations of pressure in the several bores; but we can only conclude that it may have arisen from variations in the strength of the caps. There has, no doubt, been considerable improvement in the manufacture of caps during the last few years, but there is still something to be desired as regards regularity in their strength; and an amount of variation which may not be of any great importance with regard to black powder, will have considerable effect on the nitro-compounds, and may influence some of them more than others, especially in barrels of different gauge.

As we have previously stated, we did not attempt to regulate the muzzle velocity to any given standard, but simply adopted the weight of the respective powders as recommended by their manufacturers. And if the results stated at the beginning of this article are recapitulated by a per-centage method, representing the average muzzle velocity with the 30in. barrel by 1·00 in each instance, the means of comparison will be somewhat simplified. We also add the per-centages of recoil. It will be observed that the per-centage in length of barrel differs widely from the per-centages in other respects.

PER-CENTAGES IN LENGTH OF BARREL.

	30in.	27in.	24in.	21in.	18in.
All three bores	1·00	·90	·80	·70	·60

PER-CENTAGES OF VELOCITY.

Concentrated Nitro Powder.

	30in.	27in.	24in.	21in.	18in.
12-bore	1·00	·99	·95	·94	·93
20-bore	1·00	·97	·96	·95	·95
28-bore	1·00	·98	·97	·95	·94

Bulk Nitro Powder.

12-bore	1·00	·95	·90	·90	·87
20-bore	1·00	·95	·94	·94	·91
28-bore	1·00	·97	·96	·95	·93

PER-CENTAGES OF RECOIL.

Concentrated Nitro Powder.

	30in.	27in.	24in.	21in.	18in.
12-bore	1·00	·89	·94	·90	·90
20-bore	1·00	·95	·94	·90	·90
28-bore	1·00	·94	·91	·85	·85

Bulk Nitro Powder.

12-bore	1·00	·93	·83	·83	·81
20-bore	1·00	·98	·96	·94	·93
28-bore	1·00	·99	·96	·92	·91

To what extent the velocities and recoil varied in these three bores, with the two varieties of powder and the five lengths of barrel, will be seen by reference to the following details:

VARIATIONS BETWEEN HIGHEST AND LOWEST ROUNDS AS REGARDS VELOCITY AND RECOIL.

Concentrated Nitro Powder.

Velocity:	30in.	27in.	24in.	21in.	18in.
12-bore	3%	5%	4%	4%	6%
20-bore	5 ,,	9 ,,	10 ,,	9 ,,	7 ,,
28-bore	9 ,,	6 ,,	3 ,,	3 ,,	4 ,,
Recoil:					
12-bore	5%	5%	4%	9%	12%
20-bore	12 ,,	18 ,,	15 ,,	16 ,,	17 ,,
28-bore	17 ,,	10 ,,	14 ,,	10 ,,	9 ,,

Bulk Nitro Powder.

Velocity:	30in.	27in.	24in.	21in.	18in.
12-bore	7%	6%	8%	5%	12%
20-bore	6 ,,	6 ,,	6 ,,	7 ,,	5 ,,
28-bore	7 ,,	4 ,,	3 ,,	3 ,,	4 ,,
Recoil:					
12-bore	6%	14%	18%	16%	13%
20-bore	12 ,,	10 ,,	12 ,,	19 ,,	13 ,,
28-bore	9 ,,	8 ,,	10 ,,	13 ,,	9 ,,

We have already given the full records of velocity and recoil (ten rounds of each) with the two nitro powders, together with a comparative diagram of curves.

FURTHER COMMENTS ON SHORTENED BARRELS WITH OLD AND NEW POWDERS.

(*Field*, Oct. 22, 1898; Vol. 92, p. 683.)

In four previous articles we have given particulars of the trials of three kinds of gunpowder (one black and two varieties of nitro-compounds) in guns of three gauges (viz., 12, 20, and 28 bores); and with the nitros we have cut down the barrels stage by stage, in order to ascertain what influence the reduction in length would have upon a concentrated nitro-compound in comparison with an older bulk variety.

The results appear to demonstrate that one cannot lay down any definite lines as to the behaviour of explosives when tested under changes of condition that apparently are of very small importance. We have seen that, even when the steady-going and reliable old black powder is tested in guns of different gauge, there are considerable variations in the amount of pressure developed. If you change the size of your shot, you do not merely obtain a higher or lower rate of travel through the air (consequent upon the relative power of heavy or light pellets to overcome atmospheric resistance during their progress from gun to game), but you likewise have differences in the amount of friction in the barrel; and therefore, unless you augment the powder-charge to counteract the effect of this increased friction, you meet with a reduction of muzzle velocity as well as the natural diminution of speed that is inherent on the passage of small pellets through the air. Moreover, if you enlarge the powder-charge, you not only increase the amount of stress in the barrel, but you add to the recoil rather more than double the proportion of increase of muzzle velocity—even supposing that all goes on regularly otherwise.

Again, when you discard black powders for nitros, you have these variations intensified; while each nitro appears to have its own peculiar idiosyncrasy, and to require humouring in the way of cartridge cases. The diversity of effects produced by the same caps when used with different kinds of powder is often very remarkable. In the *Field* of Feb. 7, 1891, we published particulars of a number of experiments made to ascertain the influence of a difference in strength of caps upon several varieties of gunpowder; and we found that, although with each of the explosives then tried (eight in number) the time from the blow on the cap to the exit of shot from the muzzle was shortened a little by the use of stronger primers, the variations produced in other respects were certainly conflicting.

With two of the nitro-compounds the muzzle velocity was virtually equal with both varieties of caps; whereas a third nitro had its velocity raised 4 per cent. when the stronger sample was used; while the increase of speed with the fourth nitro and the very same caps was 14 per cent. With the black powders, however, we did not anticipate much difference of behaviour, yet with the finest grain (No. 2) the muzzle velocity was raised 4 per cent. by the stronger caps, while with No. 4 grain it was only raised 1 per cent.; but most remarkable of all, there was actually a *decrease* of 6 per cent. in the velocity with the coarsest grain (No. 6) when the strong caps were used. We may add that the two varieties of caps were not one large and the other small, or containing different quantities of fulminating composition, but were similar in size, though made by different English firms, and their main difference lay in the proportions and chemical qualities of the fulminate.

Since those experiments were carried out, nearly eight years ago, the concentrated nitros have come into existence; and our recent experiments serve to indicate some of the further complications which arise from their use. In the first place, the concentrated powders occupy much less space in the chamber; and what they are wanting in bulk, they make up for by the copiousness of the gases which they evolve on combustion. This diminution of bulk in the powder sadly interferes with the simplicity of the old theory relative to the velocity of the shot being dependent upon the number of diameters of bore in

the total length of the barrel; and as each new concentrated powder appears to occupy its own special amount of space, no general rule would seem to be applicable except that of the number of evolutions of gas in the barrel.

In a previous article (Oct. 1, 1898) we stated the number of calibres or diameters of several different bores in barrels of various lengths, and also said that if the "service charges" mentioned in the schedules of the Proof Acts were more closely adhered to, the length of the cylindrical body of shot in the barrel, and of the corresponding charge of black powder, would each approximate pretty nearly to the diameter of the bore. Since then we have measured the space occupied by the charges of powder and shot in the three bores used in our recent experiments, and may now state the particulars with the concentrated as well as the bulk explosives.

No. 4 black powder, as is well known, is practically double the weight of Schultze—82grs. of the former occupying the same amount of space as 42grs. of the latter; but the corresponding charge of Ballistite is 26grs., and fills only about one-third of the space occupied by Schultze or No. 4. As the base of the cartridge cases used for the two nitros differ very much in shape, we measured the respective charges of the two powders in the paper shells, cut away from the metal base of the cases, and placed in a standing position upon a perfectly flat surface, so that the height occupied by each charge could be carefully measured. We also adopted the same method in measuring the length of the shot charges. The results, as nearly as we could ascertain them, were as follows:

LENGTH OF POWDER AND SHOT CHARGES.

	Ballistite.		Schultze.		No. 6 Shot.	
	Weight.	Length.	Weight.	Length.	Weight.	Length.
12-bore ...	26grs. =	·250 inch	42grs. =	·750 inch	1½oz. =	·750 inch
20-bore ...	22 " =	·312 "	35 " =	·812 "	⅞ " =	·781 "
28-bore ...	18 " =	·375 "	28 " =	·812 "	¾ " =	·812 "

It will be observed that the charge of Schultze powder and that of No. 6 shot are equal in length in the 12-bore, each being ·750 inch; so that in measurement they approximated closely to the diameter of the bore, which nominally is ·729 inch, but practically includes anything up to ·740. In the 20-bore, however, the length of charge, instead of being reduced in proportion to the calibre, is somewhat increased, more especially as regards the powder, although the gauge has been narrowed from ·729 down to ·615. And in the 28-bore, both powder and shot charges are ·812 in length, while the calibre is diminished to ·550.

Of course, the lengthening of the shot-charge in the narrow bore must considerably increase the amount of friction in the barrel, and thus add to the explosive force of the powder. Hence, although there is one third less powder and one-third less shot in the smallest gauge, the pressure goes up from 2·07 tons per square inch in the 12-bore to 2·81 tons in the 28-bore with Schultze; and from 2·46 tons in the 12, to 3·01 tons in the 28, with Ballistite.

Were it not for the expansive force in the powder being thus developed by increased resistance, the longer charge of shot would be much retarded in the smaller barrel, unless the charge of powder were greatly increased. And when one considers that the area of pressure behind the shot diminishes as the square of the diameter of the bore, it becomes obvious that there must be a great increase of the pressure per square inch in the smaller gauge, to impart equal velocity to the shot.

Supposing, for instance, that we take the circular area of the 12-bore to represent 1·000, the corresponding area of the 16-gauge would be ·825, of the 20-bore ·712, and of the 28-bore ·570. Many persons employ the same charges of shot in guns of very different gauge. In our trials of 12, 16, and 20 bores, two years ago, charges of 1oz. and ⅞oz. were used in all three gauges, and some people even use the 1oz. charge in 28-bores. And supposing, again, that the charge of shot in a 12-bore produced from the powder a stress equal to 2½ tons per square inch, the corresponding stress of the same charge in a 16-bore must exceed 2¾ tons per sq. in. in order to impart the same velocity; while in a 20-bore it would rise to 3½ tons, and in a 28-bore to over 4¼ tons—without making any addition for the greater amount of friction that arises from the diminution of gauge and consequent increase in length of the shot-charge.

In a previous article we stated how many diameters of gauge there are in the total length of the barrel with different bores. Now we repeat some of them, together with the number of gas expansions of the concentrated and bulk powders in equal length of barrels.

NUMBER OF CALIBRES IN LENGTH OF BARREL.

	30in.	27in.	24in.	21in.	18in.
12-bore	41	37	33	29	25
20-bore	49	44	39	34	29
28-bore	54	49	44	38	33

NUMBER OF GAS EXPANSIONS IN LENGTH OF BARREL.

		30in.	27in.	24in.	21in.	18in.
12-Bore	Ballistite	120	108	96	84	72
	Schultze	40	36	32	28	24
20-Bore	Ballistite	96	87	77	67	58
	Schultze	37	33	30	26	22
28-Bore	Ballistite	80	72	64	56	48
	Schultze	37	33	30	26	22

It will be observed that, with the 12-bore, the number of expansions of gas with Ballistite is three times as great as with Schultze, owing to the former powder only occupying one-third the amount of space that is filled by the latter; and the same proportion continues throughout the whole five lengths of the 12-bore barrel. When, however, we come to the smaller bores, it would seem as though there were a falling off in the proportion of Ballistite in the lesser gauges; for the number of gas expansions with the concentrated powder in the 20-bore, instead of being three times as many as in the case of Schultze, is but little more than 2½ times as numerous; while in the 28-bore the expansions with the concentrated explosive are not much more than double those of the bulk powder.

These changes, however, are more apparent than real, as the relative proportions of space occupied by the two powders still remain the same, viz., 3 to 1; but the length of the charges, in comparison with the length of the barrel, is much greater in the small gauges than it is in the largest bore. Thus, in the 12-gauge, the length of the powder-charge with Schultze and No. 4 black is almost identical with its diameter, while the length of the Ballistite charge is one-third that of the other two powders. In the smaller bores, however, the length of the shot charge much exceeds the diameter—that of the 20-bore being 1·04, instead of 1·00 as in the 12-gauge; while in the 28-bore the increase is to 1·08. If, however, the charges had been reduced in proportion to the calibres, the length with the 20-bore charge should have been but ·85, and that of the 28-bore only ·76, in comparison with 1·00 of the 12-bore.

In our last article (Oct. 15, 1898) we pointed out certain differences in the behaviour of the concentrated and the bulk nitro, showing that while there was a reduction in velocity in every instance with the former, whether there was a shortening of the barrel or a reduction of bore, with the bulk powder a reduction of velocity always occurred with the shortening of the barrel, but there sometimes is an increase of velocity in the smaller gauge. We repeat the tables in a somewhat altered form, and may call attention more especially to the differences between the 12-bore and the 20-bore with the 24in., 21in., and 18in. barrels.

Concentrated Powder Velocities, in feet per second, with reductions in length of barrel.

	30in.	27in.	24in.	21in.	18in.
12-bore	1257−16=	1241−44=	1197− 8=	1189−19=	1170
Differences	−33	−49	−21	−28	−12
20-bore	1224−32=	1192−16=	1176−15=	1161− 3=	1158
Differences	−14	− 6	− 5	− 8	−25
28-bore	1210−24=	1186−15=	1171−18=	1153−20=	1133

Bulk Powder Velocities, in feet per second, with reductions in length of barrel.

	30in.	27in.	24in.	21in.	18in.
12-bore	1237−62=	1175−37=	1118− 5=	1113−53=	1060
Differences	−46	−10	+33	+26	+38
20-bore	1191−26=	1165−14=	1151− 2=	1149−31=	1118
Differences	+7	+3	+4	−7	−4
28-bore	1198−30=	1168−13=	1155−13=	1142−28=	1114

We cannot but think that the difference in the number of expansions of gases has something to do with this variation in the performance of the same guns with the two classes of powder. There is also a difference in the rate of pressure at various points of the barrel with the different classes of powder.

In our previous article we gave some statistics which showed the per-centage of variations exhibited between the highest and lowest rounds recorded in the respective series of ten cartridges each, when the guns were loaded with No. 4 black powder, as well as when the two kinds of nitro-compounds were substituted. The variations with the three powders and No. 6 shot, in the 30in. barrels, were as follows:

Variations of Velocity between Highest and Lowest Rounds.

Powders.	12-Bore.	20-Bore.	28-Bore.
No. 4 Black	2%	2%	3%
Concentrated Nitro	3%	5%	9%
Bulk Nitro	7%	6%	7%

VARIATIONS OF RECOIL BETWEEN HIGHEST AND LOWEST ROUNDS.

Powders.	12-Bore.	20-Bore.	28-Bore.
No. 4 Black	4%	5%	6%
Concentrated Nitro	5%	12%	17%
Bulk Nitro	6%	12%	9%

VARIATIONS OF PRESSURE BETWEEN HIGHEST AND LOWEST ROUNDS.

Powders.	12-Bore.	20-Bore.	28-Bore.
No. 4 Black	14%	10%	25%
Concentrated Nitro	25%	8%	31%
Bulk Nitro	21%	32%	19%

As previously stated, these were the variations which occurred with the 30in. barrels; but when the barrels were shortened, other irregularities came in, and increased as the bore diminished. With the black powder there was no shortening of the barrels and the variations were comparatively small; with both nitros the variations were considerably increased, and the concentrated powder was influenced most in the smaller bores, while the bulk powder occasionally showed as much or more divergence with the largest bore. But one of the strangest features was the difference of proportion between velocity and recoil in successive rounds from the same guns.

On looking at the black powder records (on page 370) one sees few divergences, as the velocity and recoil rise or fall very nearly *pari passu*; but such differences as there are, occur mostly in the smallest bore.

With the two nitro powders, in the 12-bore gun, there are likewise not many irregularities, but the widest differences occur with the shortest barrel. In the 20-bore, however, there is a considerable change, and many are the fluctuations between velocity and recoil—the one rising where the other falls, and *vice versa*. We give some of the instances in different lengths of barrel:

VELOCITIES AND RECOIL WITH CONCENTRATED NITRO POWDER.

30in. Barrel.	27in. Barrel.	24in. Barrel.	21in. Barrel.	18in. Barrel.
Veloc. Recoil.	Veloc. Recoil.	Veloc. Recoil.	Veloc. Recoil.	Veloc. Recoil.
Ft.sec. Ft.lb.	Ft.sec. Ft.lb.	Ft.sec. Ft.lb.	Ft.sec. Ft.lb.	Ft.sec. Ft.lb.
1245 ... 22·4	1250 ... 23·0	1220 ... 21·8	1205 ... 21·0	1210 ... 22·0
1240 ... 23·0	1230*... 21·3	1200 ... 22·0	1191 ... 21·2	1205 ... 22·0
1225 ... 23·1	1225 ... 22·0	1195 ... 21·6	1149 ... 19·6	1167 ... 20·2
1210 ... 21·8	1158 ... 19·2	1172 ... 21·0	1149 ... 18·9	1163 ... 20·0
1200 ... 22·0	1145*... 22·4	1163 ... 21·4	1136 ... 20·6	1154 ... 20·4

VELOCITIES AND RECOIL WITH BULK NITRO POWDER.

30in. Barrel.	27in. Barrel.	24in. Barrel.	21in. Barrel.	18in. Barrel.
Veloc. Recoil.	Veloc. Recoil.	Veloc. Recoil.	Veloc. Recoil.	Veloc. Recoil.
Ft.sec. Ft.lb.	Ft.sec. Ft.lb.	Ft.sec. Ft.lb.	Ft.sec. Ft.lb.	Ft.sec. Ft.lb.
1210 ... 21·8	1163 ... 21·0	1154 ... 20·6	1172 ... 21·2	1132 ... 20·4
1205 ... 22·1	1163 ... 20·8	1145 ... 19·8	1167 ... 21·5	1128 ... 21·0
1190 ... 22·5	1158 ... 20·9	1141 ... 20·5	1141 ... 20·0	1134 ... 20·1
1186 ... 21·4	1128 ... 20·5	1141 ... 19·6	1132 ... 19·4	1115 ... 20·3
1181 ... 21·7	1128 ... 20·0	1136 ... 20·9	1128 ... 20·1	1115 ... 20·0

The above representations of five out of the ten rounds fired with the respective lengths of barrel will show how many were the fluctuations in the 20-bore gun. For instance, with the 27in. barrel, and the concentrated powder, in the two rounds marked with the asterisk (*), the lowest round has 85ft. less velocity than the upper one, yet the recoil is 1·1 ft.lb. higher; and, lower down, with the bulk powder, there are several instances of equal velocities and different amounts of recoil.

We imagine that these irregularities arise from the greater influence of the caps in the smaller bore. As we said before:

> In the first place there is the greater amount of friction consequent on diminution of bore, which leads to the development of greater force in the powder; and there is also increased detonative effect on the explosive used, owing to the lesser charges of powder fired in the small cartridges being acted upon by caps of the same size as those employed in cartridges of larger gauge. Hence, if one uses 50grs. of powder in the narrow bore, and 80grs. in that of wider gauge, the effect of the ignition upon the smaller charge of powder would be very similar to that of adding 60 per cent. to the quantity of fulminating composition used with the larger charge. Accordingly, the powder would be rendered additionally sensitive, so to speak, and any little excess or deficiency in the amount of detonating composition in individual caps would become intensified in the explosive results.

When there happens to be a cap that is a little stronger or weaker than the average, it produces a quicker or slower combustion in the powder. If there is a very rapid combustion, it adds to the initial movement of recoil as well as to the increase of pressure in the chamber, although the differences may be "toned down" as the shot passes up the barrel, as were the pressures of the concentrated powder in the flat-based case (shown in Mr Griffith's table, previously quoted), so that the stress in the chamber may not increase the muzzle velocity of the shot, although it may add to the "kick" of the gun.

When the 28-bore was used, the differences became more pronounced; but unfortunately some of the records were not preserved, as their bearing upon the present considerations was not then foreseen; and occasional rounds proved so erratic that it seemed unfair to the respective powders to publish such records as correct illustrations of their doings. We may mention, however, that with one round of Ballistite the velocity was 100 f.s. below another of the same series; and a similar one with Schultze where the difference amounted to 140 f.s., but we do not know what were the differences of recoil. The omission of these rounds, however, necessarily has the effect of making the 28-bore records appear more regular than those of the 20-bore, whereas we have no doubt that the reverse was the case.

There is another matter which should also be borne in mind in connection with the employment of nitro-compounds in guns of narrow gauge, and that is, that some powders which answer very well in the 12-bore give very different results in the 20-bore and smaller gauges. Examples of this came within our experience about four years ago, when we carried out a lengthy series of experiments with black and nitro powders in guns of 12, 16, and 20 gauge, in order to ascertain what would be the probable result of firing very heavy charges. We gradually increased the amount of powder used, in definite proportions, and found that with some of the powders the charges could be increased without risk For example, with Schultze, E.C., and Amberite, as well as with the black powders, the increase of stress was very moderate, whichever was the bore used; but with some others there was a vast increase of pressure in the smaller bores, and it appeared that several of the manufacturers did not possess any crusher-gauges besides the 12-bore, and had no idea that their powders would not behave alike in smaller barrels. Moreover, the same powders acted very differently when other cartridge cases were used.

One English powder, when used in English 12-bore flat-base cases, gave an average pressure of 3¼ tons per square inch; but when tried in foreign cases with conical base they averaged a trifle over 1¾ tons, or little more than half the former pressure. We had not sufficient of the foreign cases to carry the experiments further; but we had previously tested a foreign powder in foreign cases of the same description, and here there was also a considerable difference in the average results, though not to quite the same extent as with the English powder. However, average results are not everything, as guns are not usually fractured by average pressures—it is the fluctuation between highest and lowest that is to be feared; and (though there may probably be no actual burst) if a man has been firing round after round with comparatively little recoil, and then encounters a very violent "kick," he is very likely to curse the powder, whereas in reality the caps were the cause of the unpleasantness. As the same powder was used in 12, 16, and 20 bore cases, both English and foreign, we here give the per-centages of difference in pressures between the highest and lowest rounds of the same powder in the three bores:

Variations.	12-bore	16-bore.	20-bore.
English cases	6½ per cent.	13 per cent.	3 per cent.
Foreign cases	63 ,,	25 ,,	50 ,,

It has often been said, with respect to nitro powders, that "caps are the masters of the situation;" and to paraphrase an ancient saying, one may ask, "who is to keep a check on these masters?" We cannot but think that, eventually, the makers of the powders will have to take a more prominent part than they do at present in the regulation of the primers which serve to ignite their products. As was shown by illustrations published in the *Field* of April 9, 1898, representing the curves made automatically by a number of different nitro-compounds, when ignited in the barrel of our new pressure apparatus, most of the powders, concentrated as well as bulk varieties, produced curves giving a very close resemblance *when used with suitable caps*; but when unsuitable caps were substituted with one of the same powders the curve produced had a very heaped-up and exaggerated appearance, while the pressure was much higher. We think that, by means of this apparatus, together with the aid of the crusher-gauge, and the use of cartridge cases of the coned-base as well as the flat-base type, something may be done to find a reason for the peculiar behaviour of the same powders under the apparently slight change of circumstances

One alteration which we should like to see carried out in the cartridge cases for small-bore guns is to lessen the size or contents of the caps in proportion to the diameter of the bore. But in making this suggestion we cannot overlook the fact that the ammunition makers of the present day must have a very lively experience, in endeavouring to meet the requirements of the numerous explosives which are placed upon the market. Time was, and not

so long ago, when, if a new powder was brought forward, and did not suit itself to the caps that were then manufactured, so much the worse for the powder. Nowadays, however, very great pains are taken to make caps to suit the respective powders; and when, after much trouble, the manufacturers fancy they have overcome the difficulties relative to suitable cartridge cases for this or that nitro, it must be very vexatious to find that many of the complaints which arise are due to the carelessness of sportsmen themselves; as, for the sake of saving a sixpence or two per hundred, they will buy cartridges loaded in common cases, not made for the special explosive which they wish to employ, and which, however well such cases might answer with black powders, will certainly not do equally well with the various nitro-compounds.

ENERGY OF BLACK POWDERS AND NITRO-COMPOUNDS.

(*Field*, June 22, 1895; Vol. 85, p. 896.)

SIR,—I should feel much obliged if you could give me some information about the following questions: (1) What amount of energy in feet-pounds is contained in 1lb. of (*a*) smokeless powder, (*b*) black powder, (*c*) nitro-glycerine, (*d*) gun-cotton? (2) Which, in your opinion, of the smokeless powders gives the least residue? What would be the nature and the percentage of the residue left?—E. E. J. [From data given by Berthelot in "Explosives and their Power" (published by John Murray), we find that the amount of energy, per pound of explosive, in the smokeless powders (such a Schultze, E.C., S.S., and Amberite) is rather over 19 foot-tons; in black powder it is about half as much, or rather over 9½ foot-tons; in nitro-glycerine, 34½ foot-tons; and in gun-cotton 24½ foot-tons. As regards the amount of residue, we think there is no material difference between the above-named nitro powders; it is of a fibrous character, and averages about 10 per cent. We need hardly say, however, that if the charge used of one powder is heavier than that used of another, the total amount of residue would be increased, although the percentage may be the same. With black powder, the weight of the charge ordinarily used is about double that of some nitro-compounds, and nearly three times as much as others; and as the amount of residue in black powders is about 60 per cent., it will be readily seen that the black would give about twelve times as much residue as some nitro powders and about eighteen times as much as others.—ED.]

NOTES ON THE CAUSES OF "BALLING" AND OTHER IRREGULARITIES IN SHOT CHARGES.

(*Field*, Nov. 12, 1898; Vol. 92, p. 803.)

THERE recently appeared in the *Field* a letter suggesting that we should supply an article relative to the balling of shot charges. Having on various occasions published information on this subject, we did not at once act upon the suggestion, but having since looked up the reports of experiments previously carried out, we now propose to summarise the results; and, although some of the details will doubtless be familiar to many of our readers, they will probably be new to others, and so may be found worthy of repetition, as a text whereon a few comments may be made.

In the first place we may mention that we are unable to lay down any simple and definite rule as to what will produce or what will cure "balling;" for that which may cause it in one instance will not necessarily do it in another; and what may remove it with one gun will not effect a remedy where the conditions are different. Thus, the balling may arise, to a greater or less extent, from the properties of the powder, or the boring of the gun, or the quantity of shot used, or the size of the pellets, or the nature of the wads, or the length of the cartridge case, and possibly some other conditions. Consequently, it may be most unfair to a new powder, or a new kind of cartridge, to give it a general condemnation because balling of the shot has occurred in the gun of Mr A., B., or C. Nevertheless, the owners of such guns would be perfectly justified in resolving to continue the use of any other powder or cartridge which they had found did not produce so dangerous an effect in their favourite weapons; whereas they would be wrong if they assumed that all other guns must be affected in a similar way to their own.

AS TO THE NATURE OF THE POWDER.

Generally speaking, balling would be most likely to occur with a quickly-igniting powder, especially if a heavy charge of shot be used.

In the early days of smokeless powders, there was a common impression (not even now extinct) that a nitro-compound, being similar to guncotton in its chemical properties, must necessarily be very quick in ignition, and consequently dangerous. The fact is, however, that the only nitro-compound then known (Schultze) was at that time so slow in ignition that a priming of black powder was often put into the cartridge case before pouring in the nitro charge, in order to quicken the explosion; and this "amateur doctoring" became a fruitful cause of burst barrels; whereupon the powder was usually blamed, instead of the fault being attributed to the folly or ignorance of the loader. Such a quickening of ignition would be very likely to produce "balling," if it did nothing worse.

In later days, however, it has become not uncommon to explain matters by saying that nitro powders (*i.e.*, of the older bulk varieties) are "slow in ignition, but quick in combustion." And this more aptly represents the facts; for although the shot-gun nitros are, as a rule, not so slow as they originally were, they ignite much less quickly than the ordinary black powders, as may be shown by the following little table which we have framed from particulars contained in Mr Griffith's lecture on "Tests of the Strength of Gunpowders," quoted in the *Field* of Oct. 1, 1898, p. 558.

Supposing the rate of *ignition* of No. 2 black powder to be based on the time occupied between the blow on the cap and the movement of the shot for the first three inches in the barrel, and that this amount of time be represented by the number 1·00; and supposing likewise that the rate of *combustion* be based on the time occupied in traversing the next twenty-one inches—*i.e.*, up to two feet, beyond which the estimation might be less accurate—the results, as calculated from Mr Griffith's statistics, would stand thus with the five powders named:

PROPORTIONATE TIMES OF IGNITION AND COMBUSTION.

	No. 2 Black.	Condensed Nitro.	No. 4 Black.	No. 6 Black.	Bulk Nitro.
Ignition (3in.)	1·00	1·39	1·92	2·25	3·82
Combustion (21in.)	1·00	1·08	1·13	1·23	1·06

The bulk nitro here used was Schultze, but the name of the condensed nitro was not mentioned in the lecture. It will be found, on comparing the respective times, that the ignition of the bulk nitro, instead of being quicker than that of black powder (as was formerly imagined) occupied nearly four times as long as No. 2, or twice as long as No. 4, and nearly 1¾ times as long as the slow-burning No. 6; whereas in quickness of combustion (when once ignited) Schultze was only surpassed by No. 2. And we may add that the muzzle velocity is practically the same as that of No. 4 black—such being the standard up to which Schultze is expressly manufactured.

No. 2 black being thus quicker in ignition than either of the other explosives named, is the most probable of them to cause balling. But there is another powder that would be still more likely to do so if it were used in shot guns—which it seldom or never is nowadays. That powder is No. 1, of which we had a rather remarkable experience nearly ten years ago. About that time there had been a good deal of controversy relative to the shooting qualities of the guns of our ancestors, when our old friend "20,000 Shots," and several other correspondents, sent to us for trial a number of antique weapons, both flint and percussion, and we tested them for pattern and penetration (using Mr Walsh's force-gauge), as well as for velocity (taken by chronograph). We were told by "20,000 Shots" that the charges which he and his brother had been in the habit of using, in their young days, were 2drs. or 2½drs. of C. & H. Treble Seal fine-grain powder, with 1¼oz. or 1½oz. of shot; while Messrs Curtis and Harvey informed us that this corresponded with their No. 1 Treble Strong of modern days; and they very kindly supplied the powder for our trials, and assisted in the experiments.

We not only tested these guns at the target, but (by means of an Allport gauge) we ascertained the dimensions of bore throughout the full length of the barrel, and published the diameters to the thousandth part of an inch, thus revealing some of the secrets of the borers of barrels a century or more ago.

We can only briefly notice the results (which were detailed at considerable length in the *Field* of March 30, 1889), but we may mention that half a dozen rounds were fired from each barrel; that a 11-bore flint gun (single barrel), a double flint 16-bore, a double 20-bore percussion gun by Joe Manton, and a double percussion 12-bore by Westley-Richards (the property of the grandson of Colonel Hawker), all balled more or less when this fine-grain powder was used.

In order to draw a line of comparison between the guns of the past and those of modern days, we tried the same powder and charge in a 12-bore breechloader; and the balling was worse than before, owing to the powder being brought into more direct contact with the

detonating flash, by the cap being inclosed within the cartridge; besides which, there was greater resistance to the movement of the shot, through the turnover of the cartridge case, than would be likely to occur with a charge loaded at the muzzle, and this would also be likely to quicken the explosion and increase the balling. The mean velocity of the shot for a distance of 40 yards with the balled charges averaged nearly 200 ft. sec. higher than those rounds which did not ball. Various kinds of wads were used, from brown paper to punched cloth and felt, but we cannot repeat the whole of the details here.

We subsequently carried out some further experiments, and found that the old single flint gun balled eight times out of twelve with 1¼oz. of shot, several of the charges being thrown in one solid mass like a bullet, and making deep indentations in the iron target at 40 yards; but when the weight of shot was reduced to 1⅛oz. the balling diminished in frequency, and with 1oz. of shot it seldom occurred. When two felt wads were used between powder and shot, the old flint gun, instead of balling eight times out of twelve, with 1¼oz. shot, only balled twice; while there was no balling whatever with 1⅛oz. and 1oz. charges. When No. 4 black powder was substituted for the fine grain, no balling occurred, whatever wads were used. But on a smaller size of shot being substituted, the balling increased, except when an extra felt was inserted between powder and shot, whereupon the balling ceased.

All the above-mentioned experiments were carried out in cylinder barrels; but on similar experiments with No. 1 powder being made in a chokebore, it could never be induced to throw the charge in a compact mass. Now and then there might be a charge thrown in several clusters with a large number of detached pellets; but these clusters disappeared with the use of an additional felt wad, or powder of coarser grain, or a reduction in the weight of shot.

The conclusion at which we arrived was that the balling always has its origin at the breech end of the barrel, and is caused by the sudden blow imparted to the pellets when there is a very quick ignition of the explosive, as the greater portion of the powder is converted into gas before the shot has time to move. But the tendency to ball is checked by a reduction of the shot charge, and the use of sufficient elastic wadding to mitigate the impact of the blow.

Caps and Strikers.

However regular a powder may be when tried under exactly the same conditions, there are sure to be variations when the conditions are changed. Some explosives, too, are more sensitive to such changes than others. Black powders are not affected to the same extent as nitros, and the condensed nitro alluded to in the preceding table would doubtless be more affected than the bulk nitro.

Caps nowadays are more regular than they used to be; nevertheless, all are not alike, either in regularity or chemical composition. But however regular the caps may be made, they will not produce equal effects if they are ignited by means of badly-shaped strikers. Yet, what amount of pains does the average sportsman, or even the average gunmaker, take to ensure that the strikers of their guns are of such a form as will produce the best results? Makers of powders, however, have taken an infinite amount of trouble to put them in the proper track. We published in the *Field* of April 10, 1897, details of an elaborate series of experiments carried out by Mr Griffith, of the Schultze Company, showing the various effects produced in time of ignition, velocity, recoil, and misfires, by different forms of strikers; and there was a woodcut showing a little gauge made to measure the shape of the point. We wonder how many gunmakers have taken the trouble to follow out Mr Griffith's instructions!

Mr Borland, of the E.C. Company, likewise has been active in similar work, and delivered a lecture to members of the Gunmakers' Association, some particulars of which appeared in the *Field* of May 1, 1897. Mr Borland's experiments appeal to the eye, as he invented for his purpose a method of photographing the shape of the flame produced by the explosion of the cap. He said:

Fig. 3 represents a recent issue of large nitro caps, and is certainly irreproachable.

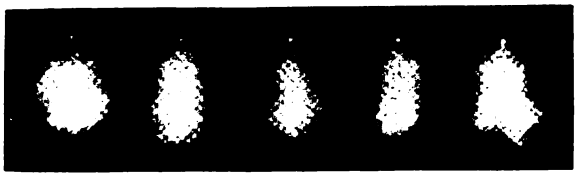


Fig. 3.—Regular Caps with Good Striker.

Fig. 4 is the same as No. 3, but the striker used for this series was of slightly smaller diameter than recommended by the makers; and the end more coned than deemed desirable by them. The moral is obvious.

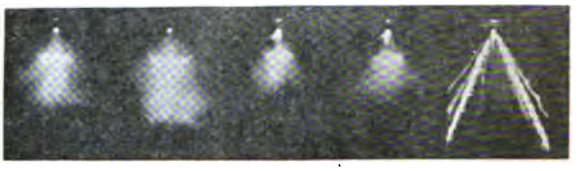


Fig. 4.—The Same Batch of Caps with Faulty Striker.

Here it will be seen that the same batch of caps which produced five flames in succession almost exactly alike, when ignited by a properly-shaped striker, gave very different shapes with a striker of different form. Two of them were tolerably regular, though not quite so full as before; two were so diminutive that they probably might cause hang-fires; and the remaining one had a long forked flame. In other instances, where the blow on the cap was heavier, the flash was much longer and more powerful, and, if injected into a charge of very sensitive nitro, might not improbably cause a balling of the shot. Yet sportsmen would be much more likely to lay the blame on the powder, instead of on the lock mechanism of the gun.

Balling may be Chiefly Due to the Gun.

It not unfrequently happens that the same cartridges will produce balling in one gun, and not in another. For instance, a few months ago a correspondent forwarded to us some cartridges, and asked if we could explain the cause of their balling so frequently. We fired them in our ordinary experimental 12-bore, and, finding no symptom of balling, asked him to send us his gun for examination. On receiving it, we found that the cone in the chamber was too short and abrupt, and we accordingly suggested that it should be lengthened and made more gradual—which we believe was done with good effect.

In some instances of this kind the occurrence of balling may cause a powder to be unjustly condemned. It will probably be remembered by some of our older subscribers, that in 1880 the use of Schultze powder and chilled shot was prohibited at Hurlingham, owing to the frequent balling of shot charges. The high wooden fence at the far side of the inclosure (distant 106 yards from the 30 yards mark) had been punched through as if with a bullet, although the boards were 1⅜ inches in thickness. After a short time it was found that the new fence was also damaged by balled shot, though neither of the supposed offenders was then in use there. Eventually, we believe, the mischief was traced to particular guns, which were rebored at the cone, and the prohibition as to the use of "sawdust" powder and chilled shot was thereupon withdrawn.

There are, however, many instances in which the same gun is used, with the same charges of powder and shot, but balling is caused by some other variation—such, for instance, as difference of wads or cartridge case. For example:

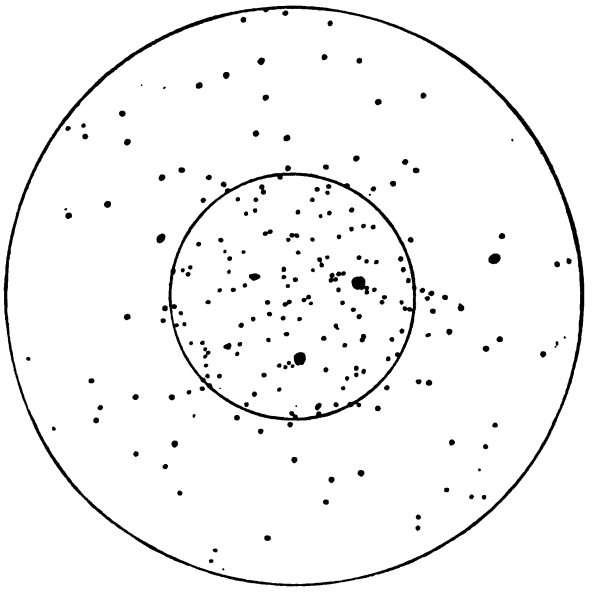
The Length of the Cartridge Case.

Several instances have been brought to our notice in which balling has been caused by the employment of longer cartridges than the gun was bored for.

When a 2½in. case is loaded with an ordinary charge of powder and shot, and the end is turned over, the cartridge will enter freely into many a 2½in. chamber; but on the gun being fired, and the case unrolled to its full length, the paper overlaps the cone, and the space through which the shot and wads have to be driven is thus reduced to considerably less than the ordinary size of the bore. Accordingly, when the shot-charge is about to quit the case, it meets with an abnormal check; the pellets have to be jammed very tightly together in order to squeeze their way through the narrow limits; the powder, instead of burning at its ordinary rate of speed, has its combustion quickened, and the rapid evolution of gases in the confined space produces an intense strain in the chamber, causing the shot to ball, if the action is strong, or crippling the gun if the action is weak. We give [see next page] a copy of a photograph exhibited by Mr Griffith of a pattern made under similar conditions in a chokebore gun.

We think it very probable that something of the same kind occurred when the balling took place at Hurlingham and the Gun Club, eighteen years ago. In those days there was, as now, a limit of the shot-charge to 1⅛oz., but there was no limit as to the quantity of powder or the weight of the gun. Some of the competitors, taking advantage of this laxity, had guns made up to 10lb. or more in weight, and used from 4drs. to 5drs. of powder; while others,

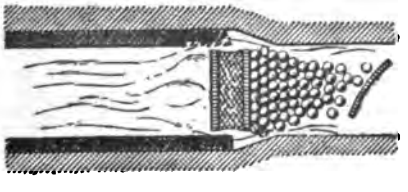
although they may not have had special guns made, doubtless crammed in as much powder as they could get into a cartridge. If, then, in so doing, they used longer cases than their guns were bored for, the mystery as to the balling would be readily explained. Be that as it may, however, a limit was put upon the charge of powder as well as the weight of the gun, and there has been no restriction since on the nature of the powder or the hardness of the shot.



As a matter of course, the employment of short or "Pygmy" cartridges in guns chambered for longer cases could not cause an overlapping of the cone; but in some guns they might possibly lead to balling—especially if the full 1⅛oz. charge were used. Such, however, is not done in the "Pygmies" now sent out; nor has it been done for a long time past. Indeed, before we ever published any notice of these cartridges, we suggested that nothing exceeding 1oz. of shot should be used in them; and Mr Lancaster readily adopted the suggestion. With 1⅛oz. of shot, in such short cases there could not be a large amount of space to devote to soft felt wads, and if the end of the chamber should happen to have been somewhat distended by wear, or if it were originally made a rather loose fit with the full-length cartridge case, the gas might possibly rush past the wads and mingle with the shot, thereby producing fusion of the pellets. Two illustrations, given further on, may explain this more clearly.

The Varieties of Wads.

Soft elastic wads have a considerable influence in preventing the "jamming" together of the shot pellets, and in lessening the amount of balling. Therefore they are much to be preferred to hard inelastic wads; although the latter may produce higher velocities as well as higher pressures, but with more irregular patterns. When the wads are too small in gauge, they are more easy to load, but much worse to shoot with; and Mr Griffith, in his lecture, showed a photographic copy of a pattern which much resembled that which is given above as regards balling, but there were not much more than half as many pellets in the smaller circle. And the lecturer said: "A tight wad is an absolute essential to good patterns. I show a view illustrating a loose wad, and the powder gas passing—a fruitful source of balling."



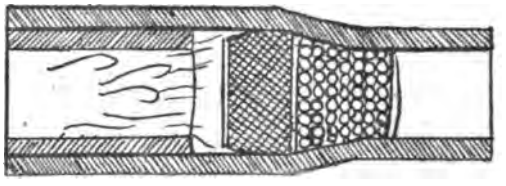
Gas rushing past Loose Wads.

Subsequently, in the course of the same lecture, Mr Griffith said:

Now a word as to Balling or Clustering. This arises from one of two causes.

1. By *Welding* of the shot.—This is caused either by violent impact against the wad, or the turnover, or the cone; or from violent powder, or from an over load. When arising from these causes, it may often be cured by using a softer wad, so as to provide a kind of spring to break the blow. It is also caused by using too long a case in the chamber, the shot being jammed together.

2. By *Fusion* of the shot itself.—This is caused by the hot gases of the powder combustion getting past the wad and among the pellets of the shot; either from too loose a wad, or from too long a chamber. A tighter



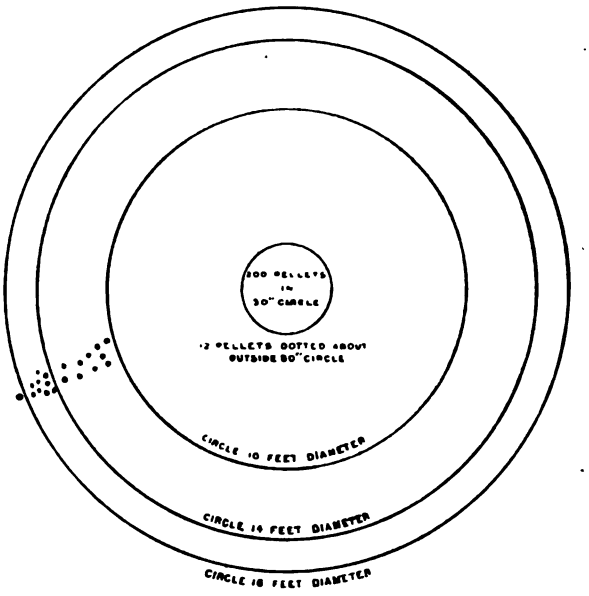
Gas checked by Expansion of Soft Felt.

wad will often cure this in the first case, and a more elastic wad in the other case. The elastic wad swells out, as is shown here, and stops the passage of the gases.

This balling is more found with the cylinder guns than with the chokes—the constriction in the latter breaking up the mass of shot somewhat, and producing clustering rather than balling. I have traced it sometimes to the fact that the actual bore of the cylinder barrel is larger than that of the choke, though of the same nominal figure.

Hard or Soft Shot.

This is a subject respecting which we carried out some extensive experiments, and published the results in the *Field* of Feb. 6, 1892. There had been some serious accidents from glancing pellets, and the


300 PELLETS IN 30" CIRCLE
12 PELLETS DOTTED ABOUT OUTSIDE 30" CIRCLE
CIRCLE 10 FEET DIAMETER
CIRCLE 14 FEET DIAMETER
CIRCLE 18 FEET DIAMETER

blame was generally laid upon the chilled shot; but in carrying out the investigation we endeavoured to ascertain whether there might not be some other factor also at work, so we tested the two kinds of shot under various conditions, such as quick and slow powders, choke-bore and cylinder barrels, and a gun with an abrupt cone. The results obtained demonstrated that the quick powder (No. 2 black) produced much more scattering of the pellets than the slow powder (Schultze); that the vagaries of the soft shot were more pronounced

than those of the chilled shot; that the abrupt cone made matters worse with both kinds of shot; and that there were very remarkable results when the quick-burning powder and soft shot were used together in the choked barrel. We give above a diagram of the pattern made by this combination on an unusually large target (rather over 16ft. in diameter), distant 28 yards from the firing point.

The circles were drawn after the round was fired; and it will be seen that out of the entire charge of 304 pellets of No. 6 shot, 200 were in the 30in. circle; while in the space between the 2½ft. and the 10ft. circle only a dozen pellets were scattered about; but beyond the 10ft. circle, on the left, there was a "string" of twenty pellets, which appeared as though they had been thrown off in a compact body by a partial balling of the charge; besides which there must have been outside this huge target about seventy pellets that passed away leaving no sign. If the barrel had been a cylinder, it is not improbable that the whole charge would have been one compact balled mass; whereas in a choked barrel, if compacted at the breech, the charge would be broken up at the muzzle of the gun.

Results of an Accident from Balled Shot.

It may be of interest to reproduce the following extract from the *British Medical Journal* of June 23, 1888. It shows at what an immense distance a mass of balled shot may do serious mischief, if it does not actually produce fatal effects. The particulars are condensed from a report given by the surgeon who attended to the injuries of the wounded man:

W. L., when leading a horse and cart along the road, heard two shots in quick succession; the second struck him in the face, and caused a roundish wound, large enough to admit a finger. The jaw was broken, and some teeth were carried away; and there was also a small wound on the cheek, which might have been made by a single pellet of shot. . . . The probe detected some hard substance, which was grasped by forceps, but crumbled under its grip. Withdrawal of the forceps was accompanied by a shower of shot falling to the floor. The blades held a lump of four pellets firmly stuck together, and much of what was then and subsequently removed consisted of pellets in twos and threes. The amount recovered was one-third of an ounce. The shot was fired from the raised bank of the Trent across a field, the distance to the road being 133 yards. It was fired at and killed a pheasant. The shooter saw the cart, but said it was out of the line of fire.

The points worthy of note are: 1, the distance—133 yards; 2, the amount of shot recovered—one-third of an ounce; 3, the statement that the man was out of the line of fire. In regard to point 3, I have been told of two other cases of strong pellets hitting persons quite out of the line of fire. As to point 2, the shot was carried in a lump; and this perhaps explains point 1. M. E. J. Behrendt, L.R.C.S. and P., Ed.
Burringham, Doncaster.

From the results of experiments and observations, we should think it probable that the victim was wounded by a charge of soft shot, fired from a cylinder barrel having a sharp cone, and loaded with a quick-burning explosive. And considering that, in the case of the charge depicted in the last illustration, there must have been seventy pellets outside the 16ft. circle at 28 yards, it is not very surprising that, at about five times that distance, the wounded man was struck by an erratic bunch of shot, although he was considered to be out of the line of fire. It shows, however, the necessity of taking every precaution to guard against the risks that may be run by the use of guns or ammunition that have a tendency to cause the balling of the shot-charge.

THE LEADING OF SHOT GUNS.

(*Field*, Oct. 22, 1898; Vol. 92, p. 684.)

Sir,—Would you kindly inform me whether a shot-gun leads inside the barrels from any defect in the gun itself? I have a 16-bore by Bland which, after even one shot, leads considerably. I use the usual charge of Schultze and chilled shot. I have had a rifle literally lined with lead after cleaning it with almond oil, although the rifling (Metford) never caught the lead before or since. Will the cleaning oil (vaseline) which I use for the shot-gun cause the barrels to lead?
Carcavellos, Portugal, Sept. 14. N. Kerr.

[In order to enlighten our correspondent and others interested in the above subject, we have made a large number of experiments. Three 12-bore shot barrels, with highly-polished bores, were used, made of three different kinds of metal, viz., Krupp's special gun steel, Whitworth's fluid pressed steel, and a very soft steel made by the Siemens-Martin process. Both hard and soft shot were used, with various kinds of wadding. The results of our trials may be summed up in a few words. The leading of gunbarrels is caused entirely by the absence of a suitable lubricant. So long as the barrel is highly polished, it matters little of what metal it is composed. In the absence of a lubricant of proper consistency, hard shot leads more than soft shot. Various lubricants were tested, their value for this purpose being in the following order: Mutton suet, Russian tallow, Webley's "Semper Idem," vaseline, almond oil, and olive oil.

Corroborative evidence of the above was obtained in the following manner: Two solid discs were turned up, and their peripheries highly polished in the lathe. One of the discs was made of crucible cast steel, the other of soft Bessemer. Bars of metal, made by melting and re-casting hard and soft shot respectively, were pressed alternately, by means of a lever and weight, against the peripheries of the rapidly-revolving discs—the pressure employed being equal to two tons per square inch of the metals in contact.

When the bar made from the hard shot was pressed against the unlubricated disc, it was quickly ground away in the form of powder. The soft lead bar resisted this disintegration to a much greater extent. All the lubricants above enumerated were successively tested upon the discs, and their anti-friction qualities proved to be in the order stated. Whether using the hard or soft steel discs, no frictional difference could be detected.

These results confirm us in the opinion, which we have so often expressed, that *soft* felt wadding saturated with grease should invariably be used, in preference to the hard felt that is so generally employed.—Ed.]

APPARATUS FOR GREASING WADS.

(*Field*, Nov. 12, 1898; Vol. 92, p. 804.)

Sir,—As I note in the *Field* of Oct. 22 that you recommend soft felt wadding saturated with grease to prevent the leading of gun barrels, and as your correspondent W. H. B., in your issue of the 29th, appears to consider this beyond the private shooter's control, I beg to inclose a very rough sketch of a wad-greasing rack which I have now used for some time for this purpose with every success.

It is briefly described thus: A A, Fig. 1, are two pieces of hard wood about 22in. long, 1¾in. deep, and ¾in. thick; the two iron screws B B, for clamping, are ⅜in. in diameter, and 8in. long; they have

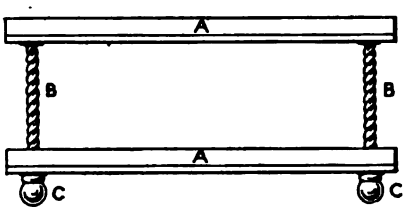


Fig I.

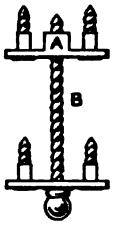


Fig II.

large flat brass heads (C C), which enables them to be easily turned by hand; they are connected to the two pieces of wood (A A) by means of brass plates and wood screws, as shown in Fig. II., the upper plate being tapped at A to receive the thread of the clamping screw B. Almost any ironmonger will supply these clamping screws complete, as shown in Fig. II. The above-sized rack will be found to hold 360 12-gauge ⅞in. felt wads, and, of course, a proportionately larger number of *Field* or card wads.

Having filled the rack, give a few turns of the screws BB, so as to clamp in the wads tightly, and then, having heated a suitable lubricant (it requires to be very hot, so that it drives right into the wads), apply it by means of a clean or new paint brush; in the latter it is as well to clip off the ends of the bristles, so as to bring them to a blunt point; this not only stiffens them, but also produces a more suitable shaped brush.

For heating purposes I find one of the small oil stoves most satisfactory, as they are so easily regulated: whilst a fairly shallow, flat-bottomed tin, shaped out of one piece, without being soldered, I consider the best receptacle in which to heat the lubricant.

The rack should be filled as full as possible, so that the rows of wads touch one another; and in applying the grease it will be found best at first to work the brush up and down in the crease between the rows rather than horizontally across them.

I have long been in the habit of thus greasing all my wads (with the exception of the card wad over the powder), and am well aware from target trials, &c., of the superior shooting thus obtained.

Benton.

TRIAL OF 28-BORE GUN.

(*Field*, April 30, 1898; Vol. 91, p. 655.)

We have lately published several letters respecting small-bore shot guns, and one of our correspondents kindly offered to lend his for trial. This gun is bored for 28-bore Perfects, and it is therefore really a 24-bore. Mr William Ford, of Birmingham, the maker of the gun, learning that we were about to make a trial, offered to supply the cartridges; these were loaded with 21grs. of powder and 1oz. of shot. We give the results:

(Barometer, 29·80in.; Thermometer—wet bulb, 54°; dry, 56°.) 28-bore gun; weight, 4lb. 3½oz.; barrels, 24in. Powder, 21grs. of E.C.; shot, 1oz. No. 5 (218 pellets). Wadding, three pink-edged wads over powder, thick card over shot. Gas pressure—average 3·45 tons per sq. inch; highest round, 3·80; lowest, 3·12 tons. Kynoch's Perfect cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	47	25	23	19	13	16	114	104	896	20·6
2	38	29	26	21	20	12	114	104	856	21·1
3	50	27	28	20	10	16	125	93	789	20·3
4	45	26	24	22	19	14	117	101	962	22·3
5	39	23	21	18	20	13	91	127	926	22·0
6	44	25	20	20	22	9	109	109	946	22·1
7	32	24	29	19	12	19	104	114	920	21·8
8	40	28	24	25	18	13	117	101	880	21·0
9	43	31	29	17	14	15	120	98	943	22·3
10	46	27	25	20	17	11	118	100	958	22·2
Average	41	27	25	20	17	14	113	105	909	21·6

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	39	28	21	22	12	16	110	108		3·80
2	50	39	22	20	18	11	131	87		3·32
3	28	36	23	15	15	8	102	116		3·14
4	45	37	25	22	20	12	129	89	Velocity and Recoil (as above)	3.50
5	38	35	22	27	22	10	113	106		3·74
6	48	33	25	25	20	15	131	87		3·12
7	52	36	19	16	11	8	123	95		3·42
8	44	30	23	28	19	13	125	93		3·80
9	31	32	26	24	9	6	113	105		3·28
10	50	33	24	22	21	12	129	89		3·40
Average	42	33	23	22	17	11	121	97		3·45

RIGHT BARREL.—Thirty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	80	42	25	20	14	9	167	51		
2	75	45	27	21	15	12	168	50		
3	64	47	26	14	17	10	151	67		
4	85	50	23	11	11	7	169	49		
5	92	49	24	16	14	11	180	38		
6	76	42	39	19	10	5	176	42	(As above.)	
7	83	52	26	13	12	8	174	44		
8	117	41	20	14	9	3	192	26		
9	86	53	22	11	13	7	172	46		
10	79	42	25	18	16	10	164	54		
Average	84	46	26	16	13	8	171	47		

LEFT BARREL.—Thirty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	98	57	22	11	5	5	188	30		
2	90	40	24	17	9	7	171	47		
3	84	50	26	20	12	9	180	38		
4	63	41	41	15	13	10	160	58		
5	70	50	34	18	12	7	172	46		
6	96	39	26	20	7	7	181	37	(As above.)	
7	102	54	20	13	9	4	189	29		
8	99	44	22	15	11	8	180	38		
9	85	47	28	18	14	11	178	40		
10	96	55	24	16	8	6	191	27		
Total ...	883	477	267	163	100	74	1790	390		
Average	88	48	27	16	10	7	179	39		

RIGHT BARREL.—Twenty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	168	29	7	3	3	0	207	11		
2	170	23	9	6	1	1	208	10		
3	124	46	16	9	6	0	195	23		
4	152	31	12	6	2	3	201	17		
5	174	15	6	0	0	0	195	23		
6	161	26	10	7	2	0	204	14	(As above.)	
7	170	27	2	5	0	0	204	14		
8	136	44	16	7	3	2	203	15		
9	172	20	10	8	0	1	210	8		
10	166	18	7	5	2	1	196	22		
Total ...	1593	279	95	56	19	8	2023	157		
Average	159	28	9	6	2	1	202	16		

LEFT BARREL.—Twenty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity.	Recoil.
1	185	22	4	3	0	3	214	4		
2	171	20	9	5	2	1	205	13		
3	175	23	5	2	0	1	205	13		
4	180	19	8	4	0	0	211	7		
5	176	23	6	3	2	1	208	10		
6	160	24	7	7	0	1	198	20	(As above.)	
7	170	22	10	5	2	2	207	11		
8	184	15	8	2	3	0	209	9		
9	177	20	7	6	1	0	210	8		
10	182	18	4	4	2	1	208	10		
Total ...	1760	206	68	41	12	10	2075	105		
Average	176	21	7	4	1	1	208	10		

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21¼ }
" " 3rd " 26 } The area of each belt, between
" " 4th " 30 } two rings, is the same as stated
" " 5th " 33¾ } above.
" " 6th " 36½ }

In our opinion 1oz. of shot is too heavy a charge for so small a bore. It will be noticed that the velocities are low, and the pressure rather high, in consequence of the length of the column of shot. We subjoin some pressures given by the definitive proof charge for this bore, which is 4drs. of black powder and 1oz. of shot, and it will be seen that the factor of safety is very small, being only the difference between 3·45 and 4·24 tons per square inch. They are as follows: 4·38, 4·22, 4·00, 4·42, 4·18 = average, 4·24 tons square inch.

TRIAL OF COMBINATION GAME AND WILDFOWL GUN.

(*Field*, Sept. 3, 1898; Vol. 92, p. 412.)

SEVERAL gunmakers have in recent years given much time and attention to the production of long-chambered 12-bores to be used for wild game, pigeon, and wildfowl shooting, and with the result that remarkably powerful guns of this class are now obtainable. Messrs J. and W. Tolley, of 59, New Bond-street, London, W., have given their especial attention to the production of a 12-bore that will fire 3in. cartridges and cartridges of ordinary length with proportionately good results. This gun, styled the "Altro," has been before the public for some little time, but, owing to the extending use to which the nitro powders are put by wildfowlers and others, for whom this long-chambered 12-bore was originally designed, certain improvements have been recently effected in it. These take the form, chiefly, of a reduction in the length of the barrels, owing to which there is also some slight decrease in the matter of weight. It is claimed, therefore, that, as now made, the gun differs from the ordinary game gun only in the matter of weight, and that with such arm the sportsman in a rough country is ready for anything that may turn up, from a woodcock to a wild goose.

Having already used one of these guns of the original model—*i.e.*, with barrels of 32in.—both at the target and in the field, I have been requested to experiment with this newer form of "Altro." The gun sent has steel barrels, 30in. in length, and weighs 7lb. 1½oz. As trials

of this sort are, of course, more valuable and conclusive if records of the shot velocities, powder pressures, and gun recoil are given, along with particulars as to the patterns and penetrative force displayed by the shot, Mr H. F. Phillips kindly undertook to ascertain these by means of the *Field* instruments. Appended is his report:

(Centre Barometer: 29·90in. Thermometer: Dry, 71°; wet, 65°.)

ORDINARY CARTRIDGES.

Kynoch's "grouse" ejector cases, containing 45grs. Amberite powder, and 1¼oz. No. 6 shot; a "Field" wad, ⅛in felt, and thin card on the powder, with a thick card over the shot.

		Average.
Velocity.....	1158, 1132, 1195 1141, 1128, 1172	= 1154 ft. sec.
Recoil	26·7, 25·0, 28·5, 26·2, 25·3, 27·0	= 26·5 ft. lb.
Pressure	2·16, 2·20, 2·18, 2·12, 2·24, —	= 2·18 tons sq. in.

LONG CARTRIDGES.

Kynoch's 3in. "Perfect" cases containing 53grs. of Amberite and 1¼oz. of No. 4 shot; a ⅛in. felt between two feltine wads on the powder, with a thick card over the shot.

Velocity.....	1260, 1255, 1245, 1266, 1277, 1250	= 1259 ft. sec.
Recoil.....	51·0, 47·0, 46·8, 49·7, 50·0, 47·1	= 48·6 ft. lb.
Pressure	3·36, 3·50, 3·14, 3·32, 3·58, —	= 3·38 tons sq. in.

Undoubtedly, the charge of 1¼oz. of shot is too heavy for a gun of this weight. A more suitable charge would be something like 48grs. of Amberite and 1⅛oz. of shot. The recoil, as, indeed, was only to be expected, proved excessive with the heavier charges, it being, as will be gathered from the figures given, nearly double that recorded by the lesser charges. We must have a sufficiency of weight to absorb recoil, and if I may offer a word of advice to brother sportsmen who desire to fire 1¼oz. of shot out of a 12-bore, it is that they, for their own comfort, should have these guns made not any lighter than 7½lb. Personally, I would incline to have them weigh a little more than this, and, assuredly, to the class of sportsmen for whom they are designed—men who can tramp the snipe ground or breast the hillside in all sorts of weather—the addition of half to three-quarters of a pound to the weight of this "Altro" would be neither here nor there. But, of course, those who prefer to use a 7½lb. gun will only be firing ½oz. less of shot if they adhere to the lessened charge mentioned above. Mr Phillips's records as to velocity are satisfactory, and bear silent testimony to the regularity of the shooting of both gun and powder.

In order to supplement the foregoing tests with proofs as to the pattern and penetration displayed by gun and cartridges I journeyed down to the London Sporting Park one day recently, and there fired a series of rounds at the target. In taking the patterns the gun was fired from a rest at the usual whitewashed "plate," the number of pellets included within a circle 30in. in diameter being counted. The card rack was the means employed for testing the penetrative force of the pellets. With regard to the card rack, I may remark in passing that provided the necessary amount of care is exercised in insuring uniformity in respect of weight, density, and dryness of the strawboard sheets, I know of no better or readier sportsman's test of the penetration of the shot gun. It may not be all that the ultra-scientist may desire, but it at once affords ocular demonstration as to the flight and treatment of the shot, whilst as a means whereby results obtained on any one day may be compared it is truly valuable to the sportsman. The card rack is extensively used at the London Sporting Park, and there Mr Watts, the courteous manager, has, with the help of his brother, recently effected several noteworthy improvements in the instrument.

In the target trials the cartridges used were exactly similar in every respect to those mentioned in the foregoing trials. The results obtained were as follows:

ORDINARY CARTRIDGES.—PATTERNS.

Right barrel: No. 6 shot.

On 5½in. circular aperture of card rack.	Total within 30in. circle.
12	207
14	206
9	226
13	253
8	206
12	214
6) 68	6)1312
11⅓ average.	218 average.

PENETRATION.

In taking this anything pierced below the tenth sheet was not counted.

Pellets.		Sheets.
1	went through	17
6	" "	16
12	" "	15
15	" "	14
14	" "	13
5	" "	12
6	" "	11
1	" "	10
60		6) 108
		18*

* Average number of sheets above 9 pierced; 1 through 17 highest.

On comparing the totals in the two left-hand columns of figures it will be seen that by the 10-sheet limit eight pellets in the series of six shots fired were disqualified. It has been found necessary to fix this limit, for otherwise these laggard pellets might so affect the averages as to render the whole trial nugatory. I have already remarked in these columns upon the injury to which some pellets are subjected in passing up the gunbarrel or by the impact of the explosion. The card rack clearly demonstrates the fact that the spherical pellets penetrate the greatest number of sheets, and it certainly is not fair to the rest to allow a few badly battered shot to dominate the position as regards the averages. But I must not touch further on this matter now; the whole subject is fraught with interest to the shooter, and certainly would seem to call for special mention at some future time.

ORDINARY CARTRIDGES.—PATTERNS.

Left Barrel: No. 6 Shot.

On 5½in. aperture.	Total within 30in. circle.
11	229
22	237
15	226
18	235
13	224
18	220
6) 97	6) 1371
16⅙ average.	228 average.

PENETRATION.

Pellets.		Sheets.
4	through	17
6	"	16
21	"	15
26	"	14
15	"	13
4	"	12
5	"	11
4	"	10
85		6) 108
		18*

* Average number of sheets above 9 pierced; 4 through 17 highest.

Trial was then made of the long cartridges—the 3in. brass cases, and loads as previously mentioned.

LONG CARTRIDGES.—PATTERNS.

Right Barrel: No. 4 Shot.

On 5½in. aperture.	Total on 30in. circle.
8	145
8	134
7	163
8	175
8	175
8	181
6) 47	6) 973
7⅚ average.	162 average.

PENETRATION.

Pellets.		Sheets.
1	through	22
3	"	21
7	"	20
7	"	19
6	"	18
4	"	17
5	"	16
4	"	15
1	"	13
1	"	10
39		6) 171
		28*

* Average number of sheets pierced above 9; 1 through 22 highest.

LONG CARTRIDGES.—PATTERNS.

Left Barrel: No. 4 Shot.

On 5½in. aperture.	Total on 30in. circle.
16	201
11	188
10	162
5	183
12	206
7	196
6) 61	6) 1136
10 average.	189 average.

PENETRATION.

Pellets.		Sheets.
2	through	22
6	"	21
8	"	20
5	"	19
11	"	18
6	"	17
1	"	16
2	"	15
3	"	14
2	"	13
46		6) 175
		29*

* Average number of sheets above 9 pierced; 2 through 22 highest.

This shooting, it must be conceded, is really very good, particularly when consideration is taken of the fact that two kinds of ammunition, widely different in character, were employed. In the first place, the light charges were loaded into *paper* cases, and the heavier ones into the *brass* cases. In the former the wadding, of course, was the same as is ordinarily used in 12-bores, but in the thinner brass case 10-bore wadding had perforce to be used. It could not, therefore, have given rise to much wonder if under such circumstances some slight disparity had been noticeable in the results obtained, and it says much for the system of boring adopted by Messrs Tolley that it should enable them to obtain such uniformly good shooting out of one gun with ammunition so widely divergent in character.

HENRY SHARP.

BURST OR BULGED GUNBARRELS.

(*Field*, Feb. 26, 1898; Vol. 91, p. 311.)

NOT a shooting season passes without our hearing of gunbarrels bulging or bursting near the muzzle. Gunmakers generally say that there is no possibility of anything of the kind happening unless there be an obstruction in the barrel. Sportsmen, on the other hand, are often equally positive that the damage done to their barrels was not caused by any obstruction

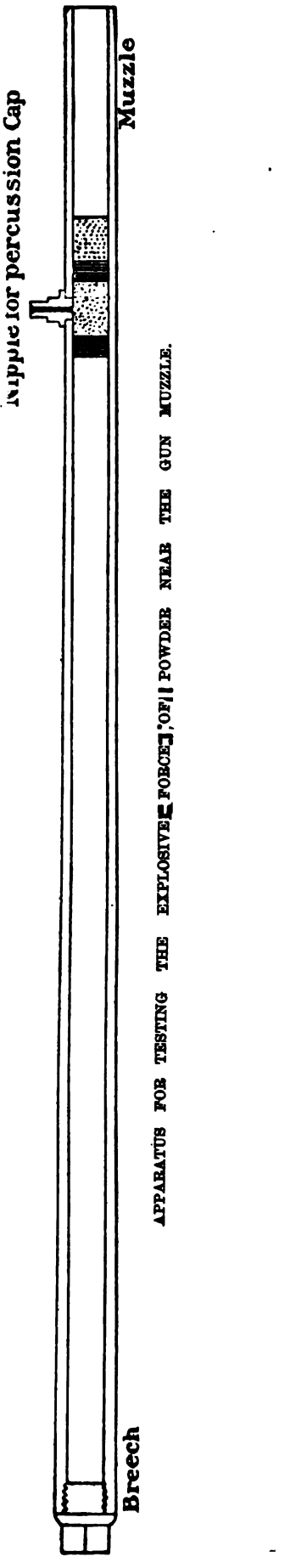
Many theories have at various times been propounded to account for these mysterious bursts or bulges, but up to the present no definite information has been forthcoming. One of these theories would explain the cause of the mischief by saying that the flash of the cap ignites only a small portion of the powder charge—just sufficient to propel the greater portion of the powder, together with the shot, up the barrel to near the muzzle; and that then a second explosion takes place, which the thin walls of the barrel are unable to withstand.

Quite recently a well-known gunmaker asked us whether, in our opinion, anything of the kind, as above set forth, could by any possibility take place; and, if it could, whether it would burst or bulge the barrel.

Acting on the axiom "Never prophesy unless you know," we declined at once to answer the question. But since then we have made many experiments, in order, if possible, to clear up the mystery. The result is that we are decidedly of opinion—first, that in the majority of cases the damage is caused by an obstruction in the barrel; and, secondly, that if supposing it were possible for the bulk of the powder to follow the shot up to near the muzzle and then explode, no damage would arise.

The sketch given on this page will explain our method of carrying out these experiments. A charge of powder with wads and 1⅛oz. of shot was placed 6in. from the muzzle—this being where the metal is generally thinnest. The breech end was closed by a screwed plug. Charges of each of the following powders were successively fired in this position by means of a strong percussion cap, viz., 42grs. of Schultze, 35grs. of fine-grain Cannonite, 26grs. of Ballistite, 30grs of Walsrode, 32grs. of Normal, and 37grs. of Shot-gun Rifleite; but not the slightest damage resulted.

We then fitted up our multiple crusher-gauge with a device for igniting the powder charge exactly under the last plug (*i.e.*, 6in. from the muzzle). The above charges of powder were each again tried, and, although the whole of the six plugs with which the crusher-gauge is fitted were provided with our small sensitive leads (which record pressures as low as one-fifth of a ton per square inch), no effect whatever was produced on any one of the crushers. The distances of these crushers from the breech were respectively: 1in., 2½in., 6in., 12in., 18in., and 24in. The result of these experiments confirms us in the opinion which we have long held, and which coincides with the opinions held by most gunmakers, that when a burst or bulge takes place in the fore part of a good gunbarrel it is invariably caused by an obstruction.



APPARATUS FOR TESTING THE EXPLOSIVE FORCE OF POWDER NEAR THE GUN MUZZLE.

STEEL BARRELS.

(*Field*, Jan. 15, 1898; Vol. 91, p. 91.)

SIR,—It appears to me that a few words respecting the science and practice of gunbarrel making may assist your readers to form a sound judgment regarding the merits of steel and Damascus barrels; and, as a barrel-maker of many years experience, I have pleasure in giving the following short account of this interesting part of the art of gunmaking.

DAMASCUS BARRELS.

A.—Damascus metal is a *mechanical mixture* of steel and iron.

B.—This mixture is effected in the following way: a number of small thin sheets of iron and steel—sheets of iron and steel being placed alternately—are firmly wired or boxed together, heated in a furnace, and welded into a solid mass.

C.—The mass is then rolled out into long thin square bars or rods.

D.—The rods are then cut up into convenient pieces.

E.—Each piece is then heated and placed in a machine, in which one end of the piece is fixed, and the piece is rotated from the other end—the result being that the piece is twisted or corkscrewed very finely.

F.—The rods are rolled of various thicknesses, according to the number of rods in the particular barrels to be made. The finer the barrels are required, the smaller is the diameter of the rods, and the greater the number of rods required for a barrel.

G.—Two, three, four, or six rods are then taken, and are heated and welded together at the sides. Thus is made a flat strip, a little more than two, three, four, or six times wider than a single rod.

H.—Damascus barrels are made usually in two parts, fore part and back part, the back part being made of thicker metal than the fore part.

I.—This is done to avoid having to roll the strip tapes from end to end, and to enable the welder to "jump" the barrel more powerfully than he would be able to "jump" a full-length barrel.

J.—The strip is heated and rolled into a ribbon.

K.—This ribbon is cut into convenient lengths, one length sufficing for a fore part or back part, as the case may be.

L.—The ribbon is then (either with or without being heated) twisted round a round rod (mandrel) in a machine, and thus formed into a spiral tube.

M.—This spiral tube is then heated and welded by "jumping" the edges of the spiral together and hammering round the sides. This process is generally effected

thus: an iron rod is inserted into one end of the spiral, and spiral placed in furnace, and, when heated sufficiently, the welder withdraws the spiral from the furnace by means of the rod, and places it horizontally under a specially-made tilt-hammer, and "jumps" it hard vertically on an iron block let into the hearth floor, in order to force the edges of the spiral together. The hammering and "jumping" are repeated alternately as many times as required. The spiral is thus made into a rough tube. The tilt-hammer is not always employed, hand-made barrels being made by a welder and one or two strikers using welding hand-hammers.

N.—The two tubes, fore part and back part, are then heated at their joining ends and welded into one, and they thus form a finished rough tube.

O.—It will be seen that (1) The essential factor of Damascus is steel. (2) That the various processes are effected with the object of interlacing the fibres of the metal and directing their length round the barrel instead of in a line with the rest of the barrel; so that, should the barrel burst, the fracture may follow the direction of the fibres and be impeded also by the interlacing of the fibres and the two metals, instead of being from end to end of the barrel, as it might be in case the fibres of the metal ran in a straight line with the length of the barrel. (3) A Damascus barrel is heated many times. (4) The welding surfaces (*a*) of the thin plates, (*b*) of the twisted rods, (*c*) of the spiral, (*d*) of the two tubes, back part and fore part, into one. (5) In each of these processes parts of the tube are liable to be overheated and the steel in them thus damaged. (6) In each of these processes small imperfections in the welding are possible and must often occur. These defects are often invisible till the barrel is finished or nearly finished, and, although the barrel may be perfectly safe, they are unwelcome eyesores to both buyer and seller of a gun.

Steel.

A.—Steel is a *chemical combination* of iron and carbon.

B.—The essential and controlling characteristic of steel is the carbon.

C.—The carbon combines with the iron, and forms an exceedingly hard, but strong, tough, and elastic compound, which is called "carbide"—the strongest alloy known.

D.—The carbide is formed throughout the steel, *not in detached grains at all*, but in a form somewhat resembling a honeycomb—the iron which the carbon has not influenced so much as to combine with it, corresponding with the honey; or, to use other familiar illustrations, the carbide may be compared to the nerves of the body, or the veins of a leaf.

E.—There are many kinds of steel. Steel is made in various ways, of various qualities, and for various purposes. There are very mild or soft steels, very hard steels, and steels of every degree of hardness between. The hardness of steel is controlled by the quantity of carbon in its composition, and this quality of steel is called its "temper."

F.—It is for the experienced steel barrel maker to determine what kind of steel is best suitable for gunbarrels. Some steels are entirely unsuitable for gunbarrels, and should therefore never be used for that purpose. Others are more or less suitable, and some particularly suitable.

G.—It will be seen from paragraphs A to D that what is effected by a merely mechanical process or series of operations (each operation liable to many defects) in the case of Damascus metal, is more surely and perfectly effected by chemical action in case of steel; and it necessarily follows that,

H.—All things being equal, those steels which are particularly suitable for gunbarrels are far superior for the purpose than the very finest and best Damascus strips.

I.—*Steel barrels are produced at one heat, and in one piece.*

J.—The prejudices against steel exist for two reasons. Old ideas still survive, regarding the nature of steel, which were current when the only kinds of steel produced were crucible cast steel for tools and shear steel for cutlery—both steels quite unsuitable for gunbarrels. But, since those days, radical changes and improvements and expansions have taken place in the manufacture, variety, use, and knowledge regarding steel. The knowledge of metallurgy which steelmakers then possessed was very limited, and the plant was equally insignificant. Now, the science and plant employed in the production of steel are of the very best, and of such a character that the quality, temper, and density of the steel can be controlled and the specially required steel produced.

Practical Comparative Tests.

I have pursued this subject exhaustively in my works, and have made many practical experiments in order to ascertain and compare the resisting powers of Damascus and steel gunbarrels, and I can say, with confidence, that the various steels employed in the manufacture of gunbarrels are superior in every respect, strength, elasticity, and wear, to the finest Damascus metal producible, whether the Damascus metal be of my own or any other manufacture.

Recrystallisation.

Recrystallisation is an absurd imagination. The condition of the carbide can be changed only by one means that has anything to do with gunmaking or shooting, namely, overheating the steel—an accident only possible in the process of welding or rolling the steel tube, or in brazing together the pair of barrels to the lug at the breech end. Overheating undoes the work of the steel maker, and changes the carbon of the carbide into graphite, and renders the part overheated similar in construction and character to that of ordinary cast iron, in which the carbon exists in loose graphitic particles.

It goes without saying that such accidents must be rendered impossible by the provision of heating furnaces arranged and controlled so that overheating is impossible. A steel barrel overheated would splinter in proof.

Under the old method of brazing together, &c., it was possible to destroy the carbide of a steel barrel; but in a proper controllable furnace it is not.

I am quite sure that anyone who understands the manufacture of steel will corroborate my experience and opinion, and I believe that a little elucidation respecting the real nature of steel used by responsible barrel makers for the manufacture of gunbarrels is the quickest way to remove unwarrantable and absurd prejudices against steel barrels.

C. G. Bonehill.

Belmont Firearms and Gunbarrel Works, Birmingham.

KYNOCH'S NEW SMOKELESS POWDER.

(*Field*, July 16, 1898; Vol. 92, p. 107.)

On the occasion of the recent visit of the Gunmakers' Association to Messrs Kynoch's works at Witton, Birmingham, the announcement was made by the chairman, to the consternation of the assembled company, that a new smokeless powder would soon be placed upon the market. Messrs Kynoch have lost no time in carrying their threat into execution, for we have been supplied with a sample of their new powder with a request to test and report on it, and we believe it will very shortly be issued to the public.

With respect to this new powder we have no startling facts to communicate to our readers. It is one of the old-fashioned class of nitro-powders—equal in bulk to its equivalent in Black powder, and almost any percussion cap or cartridge case will suit it. It throws high patterns, and gives high velocities with low and regular pressures; in smokelessness, and waterproof, and non-fouling qualities, it ranks equally with Schultze, Amberite, and other high-class powders.

We append, in tabular form, the results of a trial carried out by us a few days ago, and consider that Messrs Kynoch may be congratulated upon the success obtained by this, their first venture in the sporting powder line.

(Barometer, 29·85in.; Thermometer—wet bulb, 71°; dry, 77°.) 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 41grs.; shot, 1¼oz. No. 6 (304 pellets). Wadding, thin card, ⅛in. felt, grey cloth, and thin card over shot. Gas pressure—average 2·22 tons per sq. inch; highest round 2·46; lowest, 2·00 tons. Kynoch's medium cap cases.

Right Barrel.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft. sec.	Recoil. Ft. lb.
1	42	26	41	23	20	20	132	172	1195	29·3
2	38	30	21	25	12	19	114	190	1167	27·9
3	52	41	33	20	17	15	146	158	1205	30·0
4	44	38	30	25	23	20	137	167	1176	28·0
5	39	33	27	20	18	21	119	185	1181	29·2
6	43	40	33	18	21	17	134	170	1195	29·0
7	41	42	35	24	17	12	142	162	1172	28·2
8	47	31	25	14	18	23	117	187	1154	27·4
9	50	43	31	26	22	18	150	154	1167	27·7
10	48	37	30	27	28	23	142	162	1186	29·3
Total ...	444	361	306	222	196	188	1333	1707	11,798	286·0
Average	44	36	31	22	20	19	133	171	1180	28·6

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	89	55	43	30	20	18	217	87		2·00
2	80	48	40	36	16	13	204	100		2·20
3	90	54	47	33	17	17	243	81		2·37
4	53	35	26	40	19	21	153	151		2·28
5	84	47	39	34	22	16	204	100	Velocity and Recoil (as above)	2·04
6	92	56	45	33	11	18	236	78		2·31
7	76	51	43	34	16	18	204	100		2·24
8	86	49	45	36	19	17	216	88		2·20
9	63	40	27	21	16	15	151	153		2·46
10	82	46	41	33	22	21	201	103		2·12
Total ...	794	481	396	328	178	174	1999	1041		22·22
Average	79	48	40	33	18	17	200	104		2·22

The diameter of the 1st ring is 15 inches; area 225 circular inches.
" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36½ "
} The area of each belt, between two rings, is the same as stated above.

TRIAL OF THE E.C. No. 3 POWDER.

(*Field*, Nov. 19, 1898; Vol. 92, p. 841.)

IT is probably known to most of our readers that the E.C. powder was the second of the sporting nitro compounds brought into use in this country, and the first that was of exclusively English origin. It has undergone several modifications and improvements from time to time, at the hands of Mr W. D. Borland; and recently E.C. No. 3 has been introduced. This differs in several respects from the former issues, though, as heretofore, it is a "bulk" powder—*i.e.*, the same measure may be used as for No. 4 black; but it is now more exclusively a nitro-cellulose or guncotton powder than it has hitherto been, some of the heavy mineral salts with which it was formerly weighted being now dispensed with. Consequently it is much lighter than hitherto, its specific gravity having been reduced about 20 per cent.; so that the same measure which will hold 3drs. of No. 4 black, and which formerly required 42grs. of E.C. No. 1 or No. 2 to fill it, will now contain only about 33grs. of E.C. No. 3. One result of this diminution of mineral salts is that the powder is less likely to absorb damp; while another is that there is less solid residue in the products of combustion, and consequently less smoke.

The most striking difference, perhaps, between black powders and the nitro-compounds lies in the amount of solid residue in the products of combustion. In black powders this residue forms about 60 per cent. of the entire weight of the explosive; so that, when a charge of 3drs. is fired, there is ejected from the gun nearly 2drs. by weight of dark particles mingled with but little more than 1dr. by weight of white vapour. The consequence is that, on damp muggy days, these dark particles hang suspended in the atmosphere, and obscure the vision. When, however, we come to those nitro-compounds which are but half the specific gravity of black powder, there is not merely a reduction of 50 per cent. in the weight of the powder-charge, but also a considerable lessening in the proportion of solid residue. If, for instance, one assumed that there were 20 per cent. of solid residue in an ordinary bulk nitro, instead of 60 per cent. in a black powder, the result would be that there would be about 50grs. of solid residue to darken the air with the former, and little more than 8grs. with the latter; and if the weight of the powder charge be reduced by the removal of more solid residue, it follows that there must be less coloured smoke ejected from the gun into the atmosphere.

Such is the case with E.C. No. 3, which, with its diminished weight, may be said to be very nearly smokeless; and it also stood the heat and damp tests well. After twelve hours' drying, the larger charge of powder, used with 1oz. shot, raised the velocity about 2½ per cent.; while the damping lowered it about 5½ per cent. With the heavier charge of shot and less powder, the velocity was raised 1 per cent. by drying and lowered about 6½ per cent. by damping. The pressures also were raised or lowered, but not to a dangerous extent.

The cartridges received for trial were loaded by the E.C. Company themselves, and included three methods recommended by them. It will be observed that there are two modes of loading with the 1⅛oz. charge, and one with the 1oz. charge; and the last-named gave extraordinarily high velocities—far above our usual standard of 1160 ft.sec. in a 10 yards range. With two thick card wads in the cartridge, the 1⅛oz. charge came up almost exactly to our standard of velocity; but when a thin card was substituted for one of the thick, the velocity was considerably less. In our opinion, a grain or two of powder might well be dispensed with when only 1oz. of shot is used, unless this exceedingly high velocity is especially wished for. And, at all events, it seems rather anomalous to adopt 3grs. more of powder when you have ⅛oz. less shot. We understand, however, that what Mr Borland had in view, when suggesting the charge of 36grs. and 1oz., was the production of such a velocity as would provide an ample margin for long-range shooting, and also for the reduction, which we have proved in a recent article to occur when short barrels are used; and this with no more pressure and recoil than are obtained with the ordinary charge of 33grs. and 1⅛oz. The pressures as they stand in the records of our trials are reasonable enough; but we should not advise the charge of shot to be increased to 1¼oz. without first asking the advice of the manager of the E.C. Company.

The patterns made were good and regular on the whole, though not quite so phenomenal as mentioned by a recent correspondent, who found there were only three pellets difference between the highest and lowest rounds. As with most of the condensed nitros, the number of pellets placed in the 30in. circle is very large. The gun with which this trial was carried out was our ordinary experimental 12-bore, which with No. 4 black powder usually gives a pattern of 120 to 130 pellets from the cylinder barrel and 170 to 180 from the choke, when the full 1⅛oz. of No. 6 is used; or about 110 and 150 pellets respectively with the 1oz. charge. But it will be seen by the tabulated results of the present trials that the E.C. No. 3 averages considerably exceed those numbers.

The results of our trials with the respective charges were as follows:

1oz. OF SHOT AND TWO THICK CARD WADS.

(Barometer, 29·55in.; Thermometer—wet bulb, 51°; dry, 53°.)

12-bore gun; weight, 7lb.; barrels, 30in.; powder, 36grs. of E.C. No. 3; shot, 1oz. No. 6 (270 pellets); wadding, thick card, ⅛in. felt, thick card, thin card over shot, Eley's gas-tight cases; gas pressure—average 2·45 tons per sq. inch; highest round, 2·79; lowest 2·16 tons.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds.) Ft.sec.	Recoil. Ft.lb.
1	36	33	33	29	22	21	131	139	1206	23·3
2	42	26	37	27	16	17	132	138	1240	24·2
3	48	33	35	11	13	20	127	143	1230	23·8
4	33	30	26	25	14	16	114	156	1255	24·8
5	38	37	28	26	15	17	129	141	1235	24·0
6	44	30	28	20	14	11	123	148	1250	24·4
Average	40	32	31	23	16	17	126	144	1235	24·0

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.		Pressure per sq. inch.
1	78	61	37	23	15	16	199	71		2·52
2	60	55	45	31	19	21	191	79		2·37
3	93	46	40	18	17	20	197	73	Velocity and recoil (as above).	2·46
4	72	49	41	31	14	15	196	74		2·16
5	52	64	33	33	19	15	181	89		2·43
6	72	59	43	26	18	18	200	70		2·79
Average	71	56	40	27	17	17	194	76		2·45

The diameter of the 1st ring is 15 inches; area 225 circular inches
" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36½ "
} The area of each belt, between two rings, is the same as stated above.

1¼oz. SHOT AND TWO THICK CARD WADS.

(Barometer, 29·50in.; Thermometer—wet bulb, 48°; dry, 48°.)

12-bore gun; weight, 7lb.; barrels, 30in.; powder, 33grs. of E.C. No. 3; shot, 1¼oz. No. 6 (304 pellets); wadding, thick card, ⅛in. felt, thick card, thin card over shot; gas pressure—average, 2·61 tons per sq. inch; highest round, 2·76; lowest, 2·46 tons.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds.) Ft.sec.	Recoil. Ft.lb.
1	54	34	29	21	18	18	138	166	1154	24·4
2	48	34	25	30	21	16	139	165	1145	24·2
3	46	40	23	23	16	21	131	173	1158	24·9
4	47	29	30	19	24	14	125	179	1149	24·5
5	30	38	26	24	20	19	118	186	1163	24·9
6	51	27	40	31	15	20	149	155	1172	25·1
Average	46	34	29	24	19	18	133	170	1157	24·6

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring	5th ring	6th ring.	Inside 30 inch circle.	Outside 30 inches.		Pressure per sq. in.
1	100	60	31	33	24	19	224	80	Velocity and Recoil (as above).	2·35
2	71	62	50	27	18	11	210	94		2·67
3	84	59	42	20	28	20	205	89		2·46
4	50	68	28	37	24	29	183	121		2·58
5	92	72	36	31	16	17	231	73		2·64
6	66	49	54	40	19	12	209	95		2·76
Average	77	62	40	31	21	18	210	93		2·61

1¼oz. SHOT AND ONE THICK CARD WAD.

(Barometer, 29·55in.; Thermometer—wet bulb, 50°; dry, 53°.)

12-bore gun; weight, 7lb.; barrels, 30in.; powder, 33grs. of E.C. No. 3; shot, 1¼oz. No. 6 (304 pellets); wadding, thick card, ⅛in. felt, with thin card, and another thin card over the shot; Eley's gas-tight cases; gas pressure—average, 2·40 tons per sq. inch; highest round, 2·58; lowest, 2·28 tons.

EIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches	Velocity (10yds.) Ft.sec.	Recoil. ft.lb.
1	41	34	42	24	12	16	141	163	1107	23·0
2	36	31	37	25	15	17	129	175	1079	22·8
3	47	31	23	28	18	24	129	175	1141	24·1
4	53	44	27	25	23	20	149	155	1115	23·6
5	40	36	32	29	17	14	137	167	1099	23·2
6	48	35	39	23	18	13	145	159	1099	22·9
Average	44	35	33	26	19	17	138	166	1107	23·3

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.		Pressure per sq. in.
1	77	67	50	36	17	21	230	74	Velocity and Recoil (as above).	2·28
2	49	57	26	32	24	20	164	140		2·46
3	84	52	51	43	24	10	230	74		2·40
4	86	59	38	36	21	21	219	85		2·31
5	108	55	38	30	13	7	231	78		2·58
6	78	59	53	27	13	22	212	92		2·40
Average	79	58	43	34	18	17	214	90		2·40

36GRS. OF POWDER AND 1OZ. OF NO. 6 SHOT.

	After drying for 12 hours at 120° Fahr.					Average.
Velocity ...	1316	1271	1260	1220	1277	1255 = 1266 ft.sec.
Recoil	27·5	25·8	24·8	24·0	26·1	24·7 = 25·5 ft.lb.
Pressure ..	3·50	2·70	3·14	3·12	3·16	3·02 = 3·11 tons sq. in.
	After 12 hours' exposure to damp.					Average.
Velocity ...	1176	1158	1176	1149	1167	1167 = 1165 ft.sec.
Recoil	23·8	22·0	23·6	21·9	22·1	22·6 = 22·3 ft.lb.
Pressure ...	2·08	1·92	1·88	1·96	2·00	1·96 = 1·97 tons sq. in.

33GRS. OF POWDER AND 1¼OZ. OF NO. 6 SHOT.

	After drying for 12 hours at 120° Fahr.					Average.
Velocity ...	1099	1136	1145	1099	1099	1128 = 1118 ft.sec.
Recoil	22·7	25·5	25·8	23·5	23·2	24·0 = 24·1 ft.lb.
Pressure ...	3·08	2·61	2·79	2·82	2·49	2·85 = 2·77 tons sq. in.
	After 12 hours' exposure to damp.					Average.
Velocity ...	1020	1049	1034	1000	1060	1042 = 1034 ft.sec.
Recoil	21·0	22·2	22·1	20·0	22·9	22·3 = 21·8 ft.lb.
Pressure ...	1·88	2·04	1·73	1·92	1·83	1·73 = 1·85 tons sq. in.

NEW RIFLEITE (·450) POWDER FOR EXPRESS RIFLES.

(*Field*, Nov. 20, 1897; Vol. 90, p. 820.)

THIS powder belongs to the gelatinised class and is practically unaffected by climatic variations; moreover, being made by the Smokeless Powder Company's new process, it is entirely free from volatile solvent, and will give the same results for all time. Therefore it will stand the intense heat of India and other tropical countries without deterioration. Another good quality is that it is completely burnt in the barrel; and, as it leaves no inorganic residue, it can be used with metal covered bullets. This powder contains nothing that is soluble in water; and thus, if accidentally wetted, it assumes its normal condition on re-drying.

With the Martini-Henry rifle the 36grs. of Rifleite ·450 occupy just the correct space; and the cartridge is loaded and wadded exactly the same as the black powder cartridge. In the ·450 Taper Express the 41grs. are not equal in bulk to the usual load of black; and the case is therefore cannelured 2¼in. from the base (see accompanying woodcut).

By this means the wads are kept close to the bullet—the powder loosely occupying the 2¼in. of the case.

In adopting the charge of 41grs. for the ·450 Taper Express (which gives a muzzle velocity of 1850ft. per second with the 270grs. bullet), the company have taken into consideration the averages of the usual velocities given by 120grs. of black powder. The use of one charge of ·450 Rifleite for all the various weights and kinds of bullets will have great advantages; and the fact that the pressures are regular with all bullets, and vary very little from black with the light bullet, will give confidence to users. WAX wadding has been adopted, because it has been found by long experience to give the best results.

The shooting took place on Nov. 8, when the dry thermometer stood at 53°, and the wet at 52°, with the barometer at 30·11in. The range was at 180ft. throughout. The following records were taken in our presence:

·450 TAPER EXPRESS and ·450 MARTINI-HENRY, with black powder, for comparison. Powder, black; wads, usual; case, Eley, crimp; caps, medium and large; bullets, 270grs. and 480grs.

·450 Taper Express, 120grs. C. and H. No. 6, and 270grs. bullet, Eley's loading.

Muzzle velocity ...	1964 ...	1993 ...	1970	= average, 1976 ft.sec.
Pressure	10·08 ...	10·15 ...	10·43	= average, 10·22 tons per sq. inch.

·450 Martini-Henry, 85grs. C. and H. No. 6 black, and 480grs. bullet; our loading.

Muzzle velocity ...	first missed ...	1305 ...	1310	= average, 1307 ft.sec.
Pressure	8·06 ...	8·21 ...	7·83	= average, 8·03 tons.

NOTE.—The velocities in the Martini-Henry are rather low, and the pressures lower than usual.

·450 MARTINI-HENRY, with RIFLEITE ·450.

Powder, 36grs.; wads, jute, wax, jute; case, Eley, crimp, stabbed; cap, large; bullet, lead, 480grs.

						Averages.
Muzzle velocity	1323	1351	1333	1315	1337	= 1330 ft.sec.
" "	—	—	1353	1342	1357	= 1351 "
Pressures	—	—	7·08	6·97	7·08	= 7·04 tons.

·450 TAPER EXPRESS, with RIFLEITE ·450, and light bullet.

Powder, 41grs.; wads, jute, wax, two jutes; case, Eley, crimp, stabbed; cap, large (Eley's nitro); bullet, lead, 270grs.

Muzzle velocity	1852	1852	1904	1850	1840	= 1939 ft.sec.
" "	—	—	1908	1921	1935	= 1921 "
Pressures	—	—	9·20	9·12	10·00	= 9·44 tons.

·450 TAPER EXPRESS, with heavier bullet.

Same powder and wads as above, but solid bullet of 310grs.

Muzzle velocity	1788	1787	1785	1763	1818	= 1788 ft.sec.
" "	—	—	1855	1837	1838	= 1843 "
Pressures	—	—	10·36	9·44	9·52	= 9·77 tons.

·450 TAPER EXPRESS, with still heavier bullet.

Same as the preceding, except 41grs. of Rifleite and H.P. bullet of 325grs.

Muzzle velocity	1764	1767	1766	1782	1770	= 1770 ft.sec.
" "	—	—	1824	1824	1839	= 1826 "
Pressures	—	—	10·15	10·00	10·43	= 10·19 tons.

·450 TAPER EXPRESS, with still heavier bullet.

Same as the preceding, except 365grs. solid bullet.

Muzzle velocity	1698	1707	1708	1716	1705	= 1707 ft.sec.
" "	—	—	1745	1746	1750	= 1747 "
Pressures	—	—	10·96	10·50	10·64	= 10·70 tons.

·450 TAPER EXPRESS, with nickel-covered bullet.

Same as the preceding, except that the bullet was nickel-covered, 365grs.

Muzzle velocity	1676	1681	1668	1668	1672	= 1673 ft.sec.
" "	—	—	1654	1673	1663	= 1663 "
Pressures	—	—	10·15	10·36	10·43	= 10·31 tons.

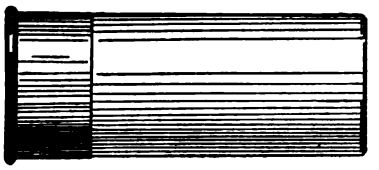
It will be observed that the pressures were taken simultaneously with the last three rounds of muzzle velocity.

The above excellent results reflect great credit upon the Smokeless Powder Company; and praise is also due to Messrs Eley Bros. for the excellent manner in which they have worked out the proper cartridge case and percussion cap to suit the new powder.

NOBEL'S "UNIQUE" CARTRIDGE.

(*Field*, April 16, 1898; Vol. 91, p. 560.)

MESSRS NOBEL, of Glasgow and Effingham House, Arundel-street, Strand, have submitted to us for trial some of their short cartridges loaded with their Ballistite powder, to which they have given the name "Unique." These cartridges are only 1⅛in. in length, the



accompanying woodcut being full size. We append the results of the trial in tabular form, and in conclusion may say that they are very good, and throughout the whole of the trial not the slightest sign of balling was noticed, although one hundred cartridges were fired from different guns to settle this one particular point.

(Barometer 29·50in.; Thermometer—Wet bulb, 46°; Dry, 48°). 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 24grs. of Ballistite; shot, 1oz. No. 6 (270 pellets). Wadding, thin card, ⅛in. felt, thick card and thin card over shot. Gas pressure—average 2·79 tons per sq. in.; highest round, 2·91; lowest, 2·64 tons; 2in. U.M.C. cases, nearly ⅛in. turnover.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	26	23	26	21	21	19	96	174	1196	23·7
2	34	24	22	22	18	11	102	168	1154	23·6
3	33	33	29	25	19	15	125	145	1172	23·4
4	26	25	25	16	15	17	92	178	1176	23·3
5	31	27	19	26	10	12	103	167	1163	22·8
6	35	32	23	25	17	9	120	150	1181	24·0
7	30	30	27	24	20	16	111	159	1158	22·5
8	35	29	24	20	15	12	108	162	1167	23·0
9	25	23	26	22	19	8	96	174	1154	22·0
10	29	27	28	27	16	8	111	159	1190	23·6
Average	31	27	25	23	17	13	106	164	1170	23·1

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	55	46	39	23	19	13	168	102		2·91
2	50	44	36	23	15	17	153	117		2·76
3	46	37	33	29	23	12	145	125	Velocity and Recoil (as above)	2·70
4	47	42	31	24	24	15	144	126		2·82
5	59	48	37	26	18	14	170	100		2·67
6	45	44	35	33	25	16	157	113		2·73
7	56	48	26	31	17	14	161	109		2·91
8	52	47	39	25	16	18	163	107		2·84
9	42	40	35	26	11	18	143	127		2·85
10	62	51	39	22	15	22	174	96		2·88
Average	51	45	35	27	18	16	158	112		2·79

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21¼ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33¾ "
" " 6th " 36¾ "

} The area of each belt, between two rings, is the same as stated above.

LANCASTER'S "PYGMIES."

(*Field*, May 7, 1898; Vol. 91, p. 694.)

MR CHARLES LANCASTER, of 151, New Bond-street, London, W., has sent a sample of his "Pygmies" for us to test and report upon. These cartridges are loaded with 28grs. of Walsrode powder and 1oz. of No. 6 shot. They were tried in a 12-bore gun with ordinary length of chamber. The velocity given is quite up to our standard, of 1160ft. per sec.; the patterns are good and regular, without the slightest sign of balling, and the pressures are perfectly safe ones.

We have lately tried a very large number of short cartridges with various charges and methods of loading, and the experience gained leads us to express the opinion that it is not advisable to use a heavier charge of shot in these short cartridges than 1oz.

(Barometer, 29·26in.; Thermometer—wet bulb, 60°; dry, 63°.)

12-Bore Gun; weight, 7lb.; barrels, 30in. Powder, 28grs. of Walsrode; shot, 1oz. No. 6 (270 pellets). Wadding: thin card, ⅛in. felt, grey cloth, thin card over shot. Gas pressure—average 2·93 tons per sq. inch; highest round, 3·14; lowest, 2·79 tons. Joyce's cases, 2⅛in. in length; cartridges, 1⅛in. in length.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	Velocity (10yds). Ft.sec.	Recoil. Ft.lb.
1	37	24	22	20	18	16	103	167	1186	22·6
2	30	30	30	21	16	16	111	159	1154	22·1
3	41	23	25	26	14	17	120	150	1193	21·3
4	33	30	28	25	20	12	116	154	1149	20·3
5	36	26	20	16	17	15	93	172	1181	22·4
6	39	31	28	24	20	16	122	148	1158	21·5
7	35	27	24	23	16	13	109	161	1167	21·0
8	42	29	26	22	19	18	119	151	1172	22·0
9	30	24	16	26	22	15	96	174	1141	20·5
10	38	26	25	21	17	14	110	160	1176	22·3
Average	36	28	24	22	18	15	110	160	1161	21·6

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30 inch circle.	Outside 30 inches.	
1	44	55	40	25	12	17	164	106	
2	59	48	37	30	20	15	174	96	
3	68	57	33	24	18	13	182	88	
4	56	50	34	27	15	11	167	103	Velocity and Recoil (as above.)
5	64	49	36	22	17	13	171	99	
6	45	42	30	26	10	21	143	127	
7	63	46	30	33	16	12	177	93	
8	49	36	24	21	16	20	130	140	
9	51	44	38	29	15	20	162	108	
10	62	57	35	27	19	14	181	89	
Average	57	48	34	26	16	16	165	105	

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21¼ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33¾ "
" " 6th " 36¾ "

} The area of each belt, between two rings, is the same as stated above.

CARTRIDGE CHAMBERS.

(*Field*, Dec. 10, 1898; Vol. 92, p. 962.)

SOME time since we were asked to write something on the subject of chambers and cones of shot guns, and the present appears an opportune moment to comply with the request. In the early days of breech-loaders the chambers were formed as shown in Fig. 1 of the accompanying illustrations, which are exaggerated in order to show more clearly the various forms. Fig. 1 had the great defect that fouling accumulated at the shoulder and prevented the cartridge case from opening out to its full extent. Fig. 2 was the next form of cone used. It is a very bad one, as it induces deformation of the shot pellets, and is very likely to cause balling. Figs. 3 and 4 show the forms of cones or entrances generally used at the present time. Fig. 5 is the correct form, and gives better results than any of the

others. By adopting this shape several advantages will accrue. The chambers may with advantage be cut less deep, the straight portion terminating at a distance of 2⅜in. from the breech end of the barrels, thus leaving the walls thicker than they otherwise would be. It will be noticed how extremely easy are the curves joining the chamber to the bore of the barrel. This shape has also been found to give better results than any other when used in pipes or passages for the conveyance of water or other fluids.

(*Field*, April 8, 1899; Vol. 93, p. 489.)

In our issue of Dec. 10, 1898, we published a short notice on the subject of cartridge chambers, and gave illustrations of the various forms in use. One of these (Fig. 5) we strongly recommended.

Fig. 1.

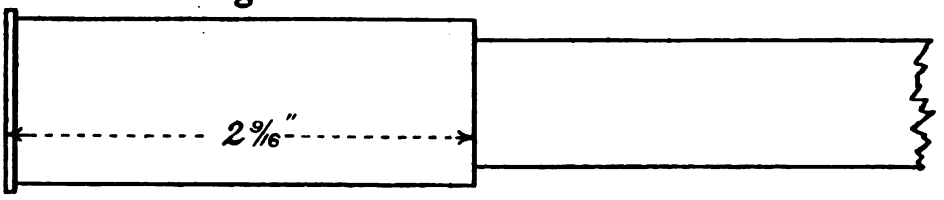


Fig. 2.

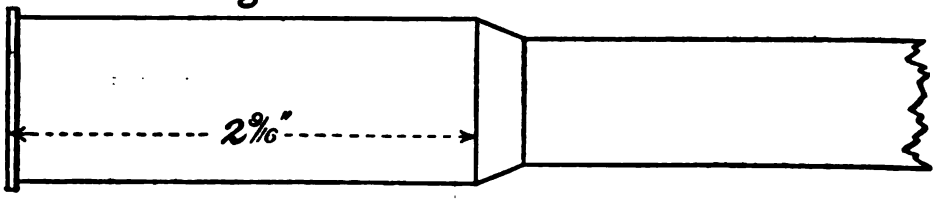


Fig. 3.

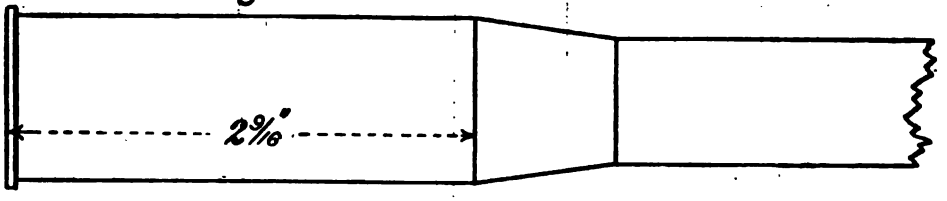


Fig. 4.

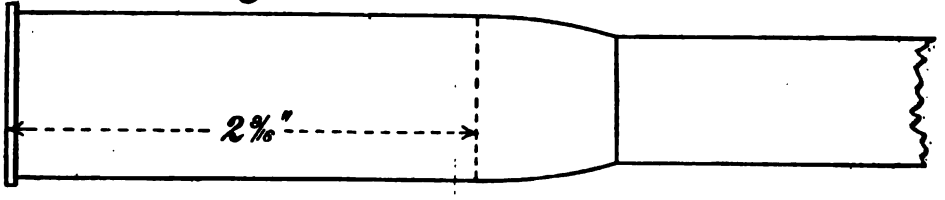
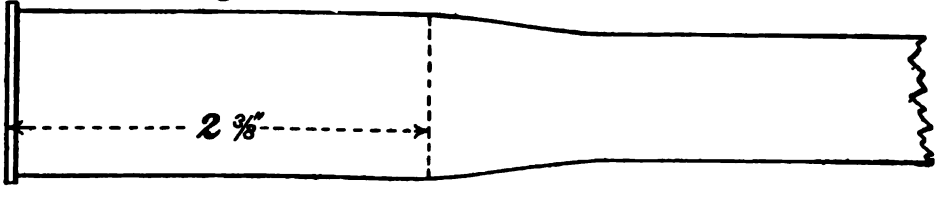


Fig. 5.



Since the notice above referred to was published, we have made many interesting experiments with chambers of various forms, and cartridges loaded in many different ways, and we now give a few of the

results. An old gun was procured having a chamber 2½in. long, with a very abrupt cone similar to that shown in Fig. 4. This gun gave a very poor pattern, averaging only ninety-eight pellets in the 30in. circle at 40 yards, as will be seen by the accompanying table, No. 1. This table does not correctly show the shooting of the gun because five rounds were patchy and balled to such an extent that the patterns could not be counted, and were therefore discarded. Pygmy cartridges were next tried, with results as shown in table No. 2. In this trial four of the rounds could not be recorded on account of the clustering of pellets. The form of the chamber of this gun was then altered to resemble that shown in Fig. 5, the only difference being that the straight portion was rather more than 2½in. long. The results both with the 2½in. and 2in. cartridges were far superior to those previously obtained; not only were the patterns higher, but they were very regular and without the slightest sign of clustering or balling.

No. 1.

(Barometer, 30·20in.; thermometer—wet bulb, 45°; dry, 47°.) 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 31grs. of Walsrode; shot, 1¼oz. No. 6 (304 pellets). Wadding, thin card, ⅜in. felt, grey cloth, card over shot. Eley's 2½in. cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	19	21	19	23	18	15	82	222	1230	28·0
2	25	23	23	18	20	17	87	217	1230	27·3
3	29	17	28	18	16	24	92	212	1210	27·5
4	38	26	20	25	14	23	109	195	1200	27·7
5	25	35	21	19	16	19	99	205	1190	27·0
6	30	31	17	32	26	20	110	194	1181	27·1
7	34	24	25	22	18	23	105	199	1176	27·4
8	23	29	18	20	13	19	90	214	1172	27·0
9	28	33	20	24	17	16	104	200	1167	26·8
10	34	20	22	30	20	18	106	198	1154	25·2
Average	29	26	21	23	18	19	98	206	1190	27·1

No. 2.

(Barometer, 30·20in.; thermometer—wet bulb, 45°; dry, 47°.) 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 26grs. of Walsrode; shot, 1oz. No. 6 (270 pellets). Wadding, 11½ field wad, ⅛in felt, card, card over shot. Joyce's 2in. cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	32	26	29	20	18	19	107	168	1181	20·9
2	36	25	31	27	17	23	119	151	1190	21·3
3	21	20	19	20	11	18	80	190	1154	20·2
4	25	29	24	17	18	12	95	175	1176	20·6
5	28	22	14	16	22	18	80	190	1163	20·4
6	23	30	21	10	15	13	84	186	1181	21·0
7	35	21	27	18	20	17	101	169	1158	20·0
8	29	24	21	21	14	20	95	175	1172	20·8
9	33	18	29	18	23	13	98	172	1154	20·0
10	21	19	28	22	19	16	90	180	1176	20·9
Average	28	23	24	19	18	17	95	175	1171	20·6

No. 3.

(Barometer, 30·24in.; thermometer—wet bulb, 46°; dry, 49°). 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 31grs. of Walsrode; shot, 1¼oz. No. 6 (304 pellets). Wadding, thin card, ⅜in. felt, grey cloth, card over shot. Eley's 2½in. cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft. sec.	Recoil. Ft. lb.
1	40	36	30	22	20	21	138	176	1186	27·0
2	33	26	28	24	20	19	111	198	1172	26·9
3	36	34	31	23	18	17	134	180	1176	26·8
4	38	26	25	29	19	24	118	186	1186	27·2
5	27	30	28	28	25	19	113	191	1181	27·0
6	34	37	28	20	24	18	119	185	1205	27·1
7	39	32	26	26	19	17	123	181	1190	27·2
8	41	38	29	25	26	23	133	171	1163	26·8
9	35	38	33	30	23	20	136	168	1167	26·9
10	43	28	27	29	21	19	127	177	1181	27·2
Average	37	33	29	26	22	20	123	181	1181	27·0

No. 4.

(Barometer 30·24in.; thermometer—wet bulb, 46°; dry, 49°.) 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 26grs. of Walsrode; shot, 1oz. No. 6 (270 pellets). Wadding, 11½ field wad, ⅛in. felt, card, card over shot. Joyce's 2in. cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	29	34	30	29	20	21	132	138	1163	20·6
2	39	32	28	23	17	18	122	143	1154	20·0
3	34	31	25	24	16	19	114	156	1176	20·6
4	28	30	26	21	20	22	105	165	1181	20·8
5	37	27	29	27	16	17	120	150	1172	20·8
6	26	28	26	28	16	16	108	162	1163	20·5
7	36	25	24	25	22	16	110	160	1158	20·2
8	38	27	25	26	19	24	116	154	1181	21·0
9	39	30	22	25	21	19	116	154	1154	20·2
10	36	33	24	21	21	23	114	156	1176	20·3
Average	34	30	26	25	19	20	116	154	1163	20·5

Merely as an experiment, and to satisfy our curiosity as to what would happen, we lengthened the chamber with the new coning tool until it would take a cartridge case 3½in long. The records given are shown in tables 3 and 4.

No fault whatever could be found with the patterns, and it will be noticed that the velocity with this long chamber is practically equal to that obtained with a 2½in. chamber.

We attribute this to the felt wad instantly expanding, as it leaves the mouth of the cartridge case, to the full size of the chamber and preventing the escape of gas to any material extent. When we consider that the soft wad has a gas pressure generally exceeding a ton upon one of its sides, and the shot charge upon the other, it is not surprising that it should act in this way.

Of course, no one possessing even the most elementary knowledge of the subject of internal ballistics would imagine that because the shot charge only weighs about an ounce that this small weight represents the resistance to the motion of the felt wad. As a matter of fact the felt wad is compressed by the powder gases on the one side, and the inertia and friction of the shot charge acting as a kind of anvil on the other, causes the wad to expand to the full extent allowed by the wall of the chamber or barrel.

TRIALS WITH WALSRODE IN 2¾IN. CASES.

(*Field*, Jan. 28, 1899; Vol. 93, p. 127.)

SIR,—I am one of the most faithful readers of your journal the *Field*, and one of your subscribers; and it would interest me greatly if you could, through your foresaid paper, give the trials made with 34 and 36 grains of Walsrode powder in 2¾in. cone cases, with 1¼oz. shot. If you would, in your published correspondence, let me know your opinion I would feel most obliged. CHR. EDM. DAVID.

[In compliance with our correspondent's request, we append the following particulars:

(Barometer, 29·5in.; thermometer—wet bulb, 53°; dry, 53°.) 12-bore gun: weight, 7lb.; barrels, 30in. Powder, 35grs. of Walsrode; shot, 1¼oz. No. 6 (338 pellets). Wadding, thin card, ⅜in. felt, ⅜in. feltine, thin card over shot. Gas pressure—average, 3·03 tons per sq. inch; highest round, 3·30; lowest, 2·79 tons. Bashmann 2¾in. cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	32	28	21	26	15	16	107	231	1230	35·0
2	36	35	33	27	21	19	131	207	1210	33·3
3	31	34	28	23	26	20	116	232	1210	33·0
4	48	32	28	21	22	14	129	209	1195	32·8
5	30	28	37	29	20	16	134	214	1190	32·9
6	42	20	32	25	17	18	119	219	1181	32·0
7	44	33	27	20	19	22	124	214	1176	31·1
8	33	40	34	29	18	24	141	197	1176	30·7
9	38	35	21	20	23	16	114	224	1163	30·0
10	33	38	25	27	25	17	123	215	1158	29·3
Total ...	372	323	286	247	206	182	1228	2152	11,889	320·1
Average	37	32	29	25	21	18	123	215	1189	32·0

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	89	49	43	29	24	27	210	128		3·30
2	73	62	44	19	28	18	198	140		3·24
3	50	49	24	30	17	16	153	185		3·20
4	84	59	31	26	23	25	200	138		3·16
5	81	33	26	38	30	27	188	150	Velocity	3·08
6	77	54	30	32	20	19	193	145	and	3·00
7	68	48	33	25	29	29	174	164	Recoil	2·91
8	55	56	40	37	23	22	188	150	(as above)	2·85
9	62	50	33	31	10	17	176	162		2·82
10	87	51	53	28	25	21	219	119		2·79
Total ...	726	511	367	295	243	221	1899	1481		30·35
Average	73	51	37	29	24	22	190	148		3·03

(Barometer, 29·2in.; thermometer—wet bulb 54°, dry 54°.) 12 bore gun: weight, 7lb.; barrels, 30in. Powder, 31grs. of Walsrode; shot, 1¼oz. No. 6 (338 pellets). Wadding, thin card, ¼in. felt, ¼in. feltine, thin card over shot. Gas pressure—average, 3·00 tons per sq. inch; highest round, 3·80; lowest, 3·40 tons. Eley's 2¾in. cases.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	47	30	22	20	18	18	119	219	1250	34·0
2	46	41	30	26	23	16	143	195	1245	33·1
3	39	38	33	23	27	19	132	206	1240	33·5
4	43	30	28	27	24	23	133	205	1235	32·7
5	44	37	27	21	17	19	129	209	1235	33·0
6	51	36	31	24	20	21	142	196	1225	32·8
7	33	34	38	21	21	19	126	212	1215	31·8
8	50	33	28	30	23	17	131	207	1215	33·9
9	43	41	29	25	19	23	138	200	1210	33·0
10	35	38	30	27	25	23	180	208	1205	32·0
Total ...	436	358	296	233	216	196	1323	2057	12,275	327·8
Average	44	36	30	23	22	20	132	206	1228	32·8

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	51	44	46	35	21	23	176	162		3·80
2	80	57	44	31	26	20	212	126		3·74
3	66	42	34	25	23	22	167	171		3·72
4	91	53	41	32	29	25	217	121		3·66
5	72	60	35	28	25	19	195	143	Velocity	3·68
6	66	58	40	36	27	24	200	138	and	3·60
7	85	68	43	30	21	17	220	118	Recoil	3·52
8	74	43	39	33	24	21	188	150	(as above)	3·43
9	59	56	48	35	28	23	198	140		3·44
10	87	68	46	27	19	16	228	110		3·40
Total ...	731	543	416	311	243	210	2001	1379		36·02
Average	73	54	42	31	24	21	200	138		3·60

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21¼ }
" " 3rd " 26 } The area of each belt, between
" " 4th " 30 } two rings, is the same as stated
" " 5th " 33¾ } above.
" " 6th " 36¾ }

Not knowing the kind of cartridge case preferred by our correspondent, we considered it advisable to use two kinds. In the first trial we used Bachmann cases, with 35grs. of powder; but 31grs. in Eley cases were found quite sufficient, the velocities being very high and exceedingly regular.—ED.]

TO REMOVE CORDITE FOULING.

(*Field*, April 1, 1899; Vol. 93, p. 464.)

THE use of boiling water is an excellent plan, but drying should be hastened by wiping with tow or flannel, and this followed by an application of good oil while the metal is still hot. The surface of a barrel allowed to dry off very soon sets up rust in the majority of cases. The cleaning rod for small calibres should be of tempered steel, very straight and elastic.

TRIAL OF NORMAL POWDER (NEW ISSUE).

(*Field*, March, 11, 1899; Vol. 93, p. 343.)

WHEN normal powder was introduced into this country we, at the request of the Normal Powder Syndicate Limited, thoroughly tested it. Our report, which was a very favourable one, was published in the *Field* of Oct. 17, 1896.

The Normal Powder Company recently placed upon the market a new and improved issue of their powder. This we were asked to test and report upon. The letter received from the manager was a typical one, inasmuch as it stated, as the letters of powder manufacturers generally do, that we should find higher velocities, splendid patterns, low pressures, and little recoil.

We stated in 1896 that the powder gave excellent results in every way, and our recent trial shows that, with regard to velocity, pattern, recoil and pressure in the barrel, the new issue gives results which are identical with those obtained with the old powder.

That the new powder is greatly superior to the old we are quite ready to admit, but it is in the qualities of smokelessness, cleanliness in the barrel, and in the absence of the unpleasant smell which formerly characterised this powder.

(Barometer 29·63in.; thermometer—wet bulb, 43°; dry, 46°.) 12 bore gun: weight, 7lb.; barrels, 30in. Powder, 31grs. of Normal; shot, 1¼oz. No. 6 (304 pellets). Wadding, thin card, ¼in. felt, grey cloth, and thin card over shot. Gas pressure—average, 2·24 tons per sq. in.; highest round, 2·55; lowest 1·83 tons.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	44	36	28	29	15	17	147	157	1131	24·7
2	28	29	29	21	19	23	107	197	1176	25·0
3	39	33	36	25	17	19	132	172	1172	24·8
4	47	34	41	18	13	17	140	164	1172	24·8
5	46	40	37	24	22	21	167	157	1167	24·2
6	38	31	35	19	18	16	123	181	1167	24·3
7	42	44	38	26	20	21	150	154	1163	24·0
8	36	33	26	22	16	19	117	187	1154	24·3
9	33	22	29	28	21	18	113	192	1145	23·9
10	49	29	23	30	14	16	131	173	1136	23·8
Average	40	33	33	24	17	19	131	172	1163	24·4

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle	Outside 30in.		Pressure per sq inch.
1	70	59	46	31	20	19	206	98		2·55
2	61	52	40	34	21	18	187	117		2·49
3	73	59	30	33	24	15	195	109		2·46
4	68	60	47	28	15	17	203	101		2·40
5	72	58	42	35	18	23	197	107	Velocity	2·28
6	74	53	41	36	19	21	204	100	and	2·30
7	69	39	49	25	20	17	183	123	Recoil	2·12
8	73	46	37	30	14	23	184	118	(as above).	2·08
9	63	34	45	19	23	18	161	143		1·96
10	67	55	44	32	22	19	198	106		1·33
Average	69	52	42	29	20	19	193	112		2·24

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21¼ "
" " 3rd " 26 " } The area of each belt, between
" " 4th " 30 " } two rings, is the same as stated
" " 5th " 33¾ " } above.
" " 6th " 36¾ "

AFTER EXPOSURE TO NIGHT AIR FOR 12 HOURS.

RIGHT BARREL.

Round.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.	Round.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	1167	24·6	7	1145	23·8
2	1163	24·4	8	1141	23·6
3	1168	24·0	9	1141	23·8
4	1158	24·1	10	1136	23·5
5	1154	24·3			
6	1149	24·0	Average	1152	24·0

LEFT BARREL.

Round.			Pressure per sq. inch.	Round.			Pressure per sq. inch.
1	.....		..... 2·34	7	.....	Velocity	..... 2·06
2	.....	Velocity	..... 2·31	8	.....	and	..... 1·96
3	.....	and	..... 2·28	9	.....	Recoil	..... 1·88
4	.....	Recoil	..... 2·24	10	.....	as above	..... 1·73
5	.....	as above	..... 2·16				—
6	.....		..... 2·12			Average	..... 2·11

AFTER DRYING 12 HOURS AT A TEMPERATURE OF 120° FAHR.

RIGHT BARREL.

Round.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.	Round.	Velocity (10 yards). Ft. sec.	Recoil. Ft. lb.
1	..... 1195	25·3	7	..... 1176	25·1
2	..... 1190	25·5	8	..... 1172	24·9
3	..... 1186	25·2	9	..... 1172	24·6
	..... 1186	25·0	10	..... 1167	24·5
5	..... 1181	25·3		—	—
6	..... 1181	25·0	Average	..... 1181	25·1

LEFT BARREL.

Round.			Pressure per sq. inch.	Round.			Pressure per sq. inch.
1	.....		..... 3·20	7	.....	Velocity	..... 1·97
2	.....	Velocity	..... 3·18	8	.....	and	..... 2·94
3	.....	and	..... 3·14	9	.....	Recoil	..... 2·91
4	.....	Recoil	..... 3·12	10	.....	as above	..... 2·88
5	.....	as above	..... 3·08				—
6	.....		..... 3·00			Average	..... 3·04

MULLERITE Nos. 1 AND 2.

(*Field*, April 22, 1899; Vol. 93, p. 569.)

MESSRS. MÜLLER AND CO., of Liège, Belgium, have submitted to us for trial two new powders which they have recently placed upon the market. These powders are known as Mullerite, Nos. 1 and 2. We have not made a chemical analysis, but are informed that both powders are composed of pure nitro cellulose, and, being thoroughly gelatinised, are practically unaffected by damp. As these powders contain little or no moisture in their composition, long exposure to moderate heat affects them but slightly. Both powders are very clean in the barrel, and do not readily set up corrosion. No. 2 is an excellent powder; it is in granular form and may be easily loaded by any ordinary cartridge loading machine. No. 1 gives superior results to any shot-gun powder we have hitherto tried and reported upon, as will be seen by the records herewith published. It will be noticed that although the velocities are about 10 ft.sec. higher than our standard, the recoils are quite moderate, as also is the gas pressure in the barrel, and the patterns are higher than any we have ever before obtained. This powder has what we consider one disadvantage—viz., it is in leaflet form, but the manufacturers inform us that they possess machines capable of loading it with accuracy and rapidity. At present both these powders must be used in Belgian cases, as there are none made in England suitable for them.

MULLERITE, No. 1.

(Barometer, 29·45 in.; thermometer—wet bulb, 43°; dry, 45°.) 12-bore gun; weight 7lb.; barrels, 30in. Powder, 33grs. of Mullerite; shot, 1oz. No. 6 (304 pellets). Wadding, thin card, ⅜in. felt, grey cloth, card over shot. Gas pressure—average, 1·77 tons per sq. inch; highest round, 2·00; lowest, 1·58 tons.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	45	40	38	28	23	21	151	153	1200	27·0
2	37	33	29	26	29	24	125	179	1163	26·6
3	29	40	37	28	22	23	144	160	1154	25·7
4	41	33	34	23	26	20	136	163	1176	26·6
5	47	39	34	25	25	21	147	157	1154	25·8
6	38	41	40	21	21	19	140	164	1158	25·8
7	45	44	38	25	24	24	152	152	1176	26·4
8	36	35	37	29	13	24	137	167	1200	26·8
9	41	49	33	27	19	18	150	154	1181	26·6
10	43	36	39	30	22	20	148	156	1190	26·7
Average	41	39	36	26	23	22	143	161	1175	26·4

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	88	79	46	28	14	19	241	63		1·63
2	79	80	44	38	18	16	241	63		1·88
3	68	61	41	39	21	21	209	95		1·58
4	90	87	38	38	19	14	243	61	Velocity	2·00
5	74	79	38	39	20	17	230	74	and	1·78
6	68	63	42	40	16	24	211	93	Recoil	1·59
7	90	69	35	27	23	25	221	83	(as above)	2·00
8	89	70	48	38	20	19	245	59		1·63
9	79	64	49	31	23	14	223	81		1·92
10	83	76	42	33	25	13	234	70		1·73
Average	81	73	42	34	20	18	230	74		1·77

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21½ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36¾ "

} The area of each belt, between two rings, is the same as stated above.

DAMP TEST, EXPOSED TO DAMP AIR FOR TWELVE HOURS.

Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.
1176	26·7	1·47	1158	25·6	1·38
1154	25·6	1·83	1149	25·6	1·33
1154	25·8	1·73	1163	25·9	1·63
1163	26·4	1·58	1172	26·5	1·53
1 81	26·6	1·47	Average:		
1167	26·0	1·63	1164	26·1	1·66

HEAT TEST, TEMPERATURE 120° FAH. FOR TWELVE HOURS.

Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.	Velocity. (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.
1210	27·0	2·16	1195	26·8	2·00
1186	26·8	2·04	1167	26·4	2·08
1190	27·0	2·20	1172	26·2	1·88
1181	26·7	2·00	1181	26·6	1·78
1200	26·9	2·20	Average:		
1176	26·5	1·92	1186	26·7	2·03

MULLERITE, No. 2.

(Barometer, 30·5in.; thermometer—wet bulb, 53°; dry, 58°). 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 33grs. of Mullerite; shot, 1oz. No. 6 (304 pellets). Wadding, thin card, ⅜in. felt, grey cloth, and thin card over shot. Gas pressure—average 2·52 tons per sq. inch; highest round, 2·67; lowest, 2·34 tons.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in circle.	Outside 30in.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.
1	41	31	29	22	28	24	123	181	1190	26·7
2	33	33	26	30	26	20	127	177	1210	27·5
3	44	40	34	29	19	18	147	157	1167	25·9
4	35	30	24	26	20	30	115	189	1186	26·6
5	36	29	21	25	25	23	111	193	1210	27·1
6	47	38	32	20	27	19	137	167	1167	26·0
7	40	34	18	18	23	14	110	194	1181	26·3
8	37	41	30	23	21	23	131	173	1176	25·8
9	45	31	32	27	18	21	135	169	1200	27·0
10	49	44	38	19	24	16	150	154	1172	26·2
Average	41	35	28	24	23	21	129	175	1186	26·5

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ing.	Inside 30in. circle.	Outside 30in.		Pressure per sq. inch.
1	70	71	48	34	22	13	223	81		2·55
2	61	64	35	38	19	17	198	106		2·49
3	84	70	50	20	17	12	224	80		2·67
4	80	68	40	26	20	19	214	90	Velocity	2·43
5	58	61	54	40	26	20	213	91	and	2·61
6	63	45	39	32	23	18	179	125	Recoil	2·58
7	81	67	52	39	18	21	239	65	(as above)	2·34
8	75	58	43	32	11	14	208	98		2·61
9	53	53	44	36	25	16	186	118		2·52
10	74	60	39	29	15	16	202	102		2·43
Average	70	62	44	33	20	17	208	96		2·52

DAMP TEST, EXPOSED TO NIGHT AIR FOR TWELVE HOURS.

Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.
1136	25·1	2·16	1154	25·6	2·31
1176	25·9	2·52	1163	26·0	2·37
1163	25·8	2·28	1141	25·4	2·43
1128	25·0	2·00	1132	25·0	2·23
1149	25·3	2·37	Average:		
1167	25·7	2·20	1151	25·5	2·30

HEAT TEST, TEMPERATURE 120° FAH. FOR TWELVE HOURS.

Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.	Velocity (10 yards). Ft.sec.	Recoil. Ft.lb.	Pressure per sq. inch.
1235	26·8	3·18	1215	27·0	3·30
1230	23·2	3·10	1235	28·6	3·24
1200	27·3	3·26	1210	26·9	3·16
1225	27·9	3·20	1300	27·2	3·10
1295	26·8	3·12	Average:		
1230	28·0	3·03	1219	27·8	3·17

LIGHT LOADS OF DIAMOND POWDER.

(*Field*, July 22, 1899; Vol. 94, p. 147.)

FROM Messrs Curtis and Harvey we recently received the following communication:

Last season a sportsman who still uses black powder requested us to load some game cartridges with the lightest load of powder and shot we thought would prove effective on the field; this we did, and, as his report was so favourable, we thought you might be interested in the subject. We are, therefore, sending fifty ejector cartridges, medium caps, loaded with 2¼drs. Diamond ◇ No. 2 and ⅞oz. 5½ soft shot, and shall be greatly obliged if you will test them and favour us with your report.

We tested the cartridges alluded to in the above, and append the results in tabular form. It will be noticed how exceedingly regular are the records of velocity, recoil, and pressure in the barrel. The greatest variation in velocity in ten rounds is only 20 ft.sec., in recoil only ½ ft.lb., and the difference between the highest and lowest pressure is only ¼ ton per square inch in a similar number of rounds. Records such as these have never been obtained with any kind of smokeless powder, and if we are to judge by recent events at Edinburgh and Bisley (where the pressure in the barrel was increased from 14 or 15 to upwards of 30 tons per square inch by merely making a slight alteration in the bullet), it will be a long time before the smokeless will beat the good old black powder for regularity and reliability.

(Barometer, 29·68in.; thermometer—wet bulb, 67°; dry, 72°.) 12-bore gun; weight, 7lb.; barrels, 30in. Powder, 2¼drms. of Diamond No. 2 shot, ⅞oz. No. 5½ (213 pellets). Wadding, black and pink card, ¼in. felt, ¼in. felt, thick card, and thin card over shot. Gas pressure—average 2·31 tons per sq. inch; highest round, 2·46; lowest, 2·20 tons.

RIGHT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 30in.	Velocity (10 yards) Ft.sec.	Recoil. Ft.lb.
1	34	37	19	22	17	15	102	111	1 45	23·0
2	32	33	21	20	18	19	111	103	1240	22·7
3	43	26	22	13	20	10	109	104	1240	22·9
4	30	25	17	18	13	12	90	123	12.0	22·7
5	41	32	19	24	18	16	116	97	1210	22·5
6	46	30	20	19	15	18	115	98	1235	22·9
7	29	26	24	15	10	12	94	119	12 0	22·6
8	37	39	18	16	11	10	110	103	1230	22·7
9	33	26	14	13	17	21	86	127	1230	22·5
10	39	30	24	21	18	15	114	99	1225	22·6
Average	36	31	20	18	16	15	105	108	1236	22·7

LEFT BARREL.—Forty Yards Pattern.

Round.	1st ring.	2nd ring.	3rd ring.	4th ring.	5th ring.	6th ring.	Inside 30in. circle.	Outside 20in.		Pressure per sq. in.
1	44	40	22	19	13	12	125	86		2·46
2	51	31	31	26	15	12	139	74		2·43
3	43	36	37	25	17	15	141	72		2·37
4	49	38	27	20	15	18	134	79	Velocity	2·34
5	62	43	23	18	18	14	146	67	and	2·31
6	64	46	18	15	17	13	143	70	Recoil	2·28
7	50	42	22	14	16	15	128	85	(as above)	2·28
8	42	45	30	18	16	17	135	78		2·24
9	40	48	35	21	22	9	144	69		2·24
10	55	44	31	16	13	16	146	67		2·20
Average	50	41	28	19	16	14	138	75		2·31

The diameter of the 1st ring is 15 inches; area 225 circular inches.

" " 2nd " 21¼ "
" " 3rd " 26 "
" " 4th " 30 "
" " 5th " 33½ "
" " 6th " 36¼ "

} The area of each belt, between two rings, is the same as stated above.

VELOCITY OF SHOT.

(*Field*, April 1, 1899; Vol. 93, p. 464.)

BASHFORTH'S tables enable us, as all know, to ascertain readily the muzzle velocity of a rifle bullet from the mean velocity recorded by the chronograph over a given range of, say, 60 yards from the gun. But for shot guns these tables do not apply, and it is generally believed that for such projectiles as a charge of small shot no fixed relation exists between the muzzle velocity and the mean velocity over a given distance. Within limits this is true. It is not possible to bring any individual shot under a general law such as that on which the tables for rifle bullets are founded, for a charge of small shot, which leaves the gun in cylindrical form, breaks up irregularly from various causes. Sometimes it begins to break up and to scatter as soon as it is clear of the gun; sometimes the mass is projected a considerable distance before the scattering action begins to take a marked effect. In the latter case the velocity is better maintained than in the former; but when we take a mean of not fewer than five shots, we find that the e irregularities correct one another, so that this mean shows a definite fixed relation among the velocities over different distances. That is to say, if we know the velocity over a range of, say, 10 yards, we can calculate with accuracy the muzzle velocity, and the velocity over another range, of 20 mètres, for example. This being so, we can calculate and form a table from which, when we have learned the velocity by actual measurement over one range, we can by inspection ascertain the velocities over other ranges, and at the muzzle of the gun. Such a table I give hereafter. Its uses are obvious, and they are of considerable practical importance. The velocities obtained from this table may not, for the reason already given, be exactly correct for each individual shot. But if all is as it should be, that is, provided there be no fault in the caps, the cases, the wadding, or the powder, they will not be far wrong, while the mean of not less than five shots will agree with the figures in the table within limits of variation so narrow as to be of no practical importance. Thus the table shows what the velocities of each individual shot should be. Here lies one of the most important uses of the table. For if we take the actual readings of the Jervis Smith chronograph over all the ranges and compare them with the figures in the table, we detect at once any irregularity or defect in the shooting that would not be otherwise discovered.

In my investigations into the subject of relative velocities over certain given distances my first experiments had for their object the direct measurement of the muzzle velocity. The testing ranges of the Messrs Curtis's and Harvey are exceptionally well provided with measuring instruments of precision, there being, among other instruments of that class, no fewer than six chronographs, of which two are Jervis Smith's, made by Elliott Bros., with all the latest improvements. Having these at my disposal, my task was not a very difficult one. Time and care only were required to obtain accurate results.

Measurements of velocity were first taken over the 6in. between two electrical circuits, one of which was placed 1in. behind the muzzle and the other 5in. beyond the muzzle. A sufficient number of shots having been fired to give a reliable mean value, the first circuit was shifted forward 1in. to the muzzle and the second brought back 1in., giving a distance of 4in. beyond the muzzle over which the velocity was next to be measured. The average of the records over these two distances being practically equal, this latter distance was finally adopted for direct muzzle velocity measurements. Curtis's and Harvey's Diamond No. 4 powder was used in the whole series of these experiments, the shot being No. 6 chilled, of 270 pellets to the ounce. The charges were 3drs. (82grs.) and 1⅛oz.

The muzzle velocity having been in this way determined, the electrical circuits were set 1ft. apart—that is, at the muzzle, at 1ft., at 2ft., and at 3ft. from the muzzle, and records taken of the same shot. The distances were gradually increased till the range of 10ft. was covered, chronographic records of ten shots being taken for every change of distance. These experiments were exceedingly interesting, because the chronographic measurements showed, in some degree at least, what happens to a charge of shot immediately after it leaves the gun. Up to about 4ft. 6in. from the muzzle the velocity continues to increase, though at a slow and, of course, a diminishing rate. Over the next 2½ft., or thereabouts, the velocity is practically constant. Beyond a point about 7ft. distant from the muzzle the velocity begins to decrease, and that rapidly, the falling off over the interval between

the 7ft. and the 10ft. ranges being considerable. In speaking of these distances I have said there or thereabout, because there are slight variations in the behaviour of individual shots, due probably to the charge of shot breaking up more or less quickly.

It is not, I think, difficult to account for this behaviour of the projected shot charge. When the shot has issued from the muzzle the resistance due to friction in the barrel ceases, while the gas pressure upon the moving mass of shot, though greatly reduced and rapidly diminishing, is maintained for a time. Moreover, the powder gases, having a velocity greater than that of the shot, get in front of the latter, driving the air before them, so that for a time there is no atmospheric resistance to overcome; therefore the velocity increases. Then follows a time during which the impelling force and the atmospheric resistance which is beginning to come into operation are practically equal, and the velocity is consequently constant over that period of time.

Among the discoveries made in these experiments is the fact, which is of considerable practical importance, that the chronographic records of velocity over the whole distance of 10ft. from the muzzle of the gun are, for all practical purposes, the same as those for the first 4in. from the muzzle. Knowledge of this fact greatly simplifies the taking of muzzle velocities by direct measurement, for a chronographic measurement over a range of 10ft. is much more easily taken than one over 4in.

The next set of experiments were intended to throw some light on the rate of loss of velocity over sporting ranges. With this view the electrical circuits or "screens" were set up—(1) at the muzzle of the gun, (2) at 10ft., (3) at 10 yards, and (4) at 20 mètres from the muzzle. To obtain reliable results Black powder, Curtis's and Harvey's Diamond No. 4, was used, and the cartridges were loaded with great care, to get uniformity as far as possible. Further, arrangements were made to eliminate the influence of wind on the shot. It is worthy of mention, too, that the Boulengé chronograph was, in this series of experiments, used in conjunction with the Smith, to check the readings of the latter. It will be easily understood that when two sets of wires are used on one screen the two instruments, however well adjusted, will not, or at least may not, give the same record, because the wires of both instruments are not broken by the same pellet. This difficulty was got over by using fine silk-covered wire for the screens, and twisting the wires of the different circuits together tightly, so as to form, for breaking purposes, a single wire. A pellet striking this combination necessarily broke both circuits. A further precaution was to place an iron plate having a central opening 8in. square in front of the screens. This was done to ensure the wires being broken by the central pellets of the charge. The face of the plate was whitewashed, and every shot that was not well centred, as shown by the pattern, was rejected.

With these arrangements for correct measurement a very large number of shots were fired. From the records of velocity so obtained the mean values were calculated. These "means" I assumed to be a sound basis whereon to found a table of relative velocities over the ranges dealt with, namely, 10ft. (muzzle velocity), 10 yards, and 20 mètres.

The grand average of all the series of shots fired under these conditions gave 1222ft. a second over the 10ft. range; 1160ft. a second over the 10 yards range, and 1005ft. a second over the 20 mètres range.

The velocity over the 10ft. range being for all practical purposes the true muzzle velocity, the falling off in velocity over the 10 yards range (from 1222ft to 1160ft) is 5·073 per cent. Knowing what the percentage of loss over the 10 yards range is for a muzzle velocity of 1222ft. a second, we may calculate the loss over the same range for any other other muzzle velocity.

For example, if it be required to find the percentage of loss for a muzzle velocity, of say, 1240ft. a second, we have the relation:

$$5{\cdot}073 : x :: 1222^2 : 1240^2,$$

the resistance of the air varying as the square of the velocity of the shot. That is

$$\log. x = \log. 5{\cdot}073 + \log. 1240^2 - \log. 1222^2,$$

and generally,

$$\log. x = \log. 5{\cdot}073 + \log. a^2 - \log. 1222^2,$$

a being the muzzle velocity for which it is required to find the mean velocity over the 10 yards range, and x the percentage of loss with that muzzle velocity.

From the foregoing we find that the percentage of loss with a muzzle velocity of 1240ft. a second is 5·223. Substracting this loss, we get 1175ft. a second as the velocity over the 10 yards range.

On such data, and in this way, the following table was calculated. To whatever objections that may be raised against it on theoretical grounds I have the answer that it has stood the test of experience. The table has been in daily use at our chief testing station during the last fourteen months, in which time thousands of shots have been fired, and the records of velocity obtained, when the cartridges have been what they should be, have always agreed closely, often exactly, with the values tabulated. In using this table, it is to be borne in mind that it has been calculated for No. 6 chilled shot, of 270 pellets to the ounce.

TABLE OF VELOCITIES IN FEET A SECOND.

Muzzle.	10 yards.	20 mètres.	Muzzle.	10 yards.	20 mètres.
1000	966	885	1142	1091	966
1002	968	887	1144	1093	968
1004	970	889	1147	1095	969
1006	971	890	1150	1098	970
1008	973	892	1152	1100	972
1010	975	893	1155	1103	973
1012	977	894	1157	1105	974
1014	979	896	1160	1107	976
1016	980	896	1163	1109	977
1018	982	897	1165	1111	978
1020	984	898	1168	1114	980
1022	986	899	1171	1117	981
1025	988	901	1174	1119	982
1027	990	902	1176	1121	984
1029	992	903	1179	1123	985
1031	994	904	1182	1126	986
1033	996	906	1185	1128	988
1035	998	907	1188	1131	989
1037	1000	908	1190	1133	990
1040	1002	910	1193	1136	992
1042	1003	911	1196	1138	993
1044	1005	912	1199	1141	994
1046	1007	913	1202	1144	995
1048	1009	915	1205	1146	997
1050	1011	916	1208	1148	998
1053	1013	917	1211	1151	999
1055	1015	919	1214	1153	1001
1057	1017	920	1216	1155	1002
1059	1019	921	1219	1157	1003
1062	1021	923	1222	1160	1005
1064	1023	924	1225	1162	1006
1066	1025	925	1228	1165	1007
1068	1027	927	1231	1167	1009
1071	1029	928	1234	1170	1010
1073	1031	929	1238	1173	1011
1075	1033	930	1241	1176	1012
1078	1035	932	1244	1178	1014
1080	1037	933	1247	1181	1015
1082	1040	934	1250	1183	1016
1085	1042	936	1253	1186	1018
1087	1044	937	1256	1188	1019
1089	1046	938	1259	1191	1020
1092	1048	940	1263	1195	1022
1094	1050	941	1266	1197	1023
1096	1052	942	1269	1200	1024
1099	1054	944	1272	1202	1025
1101	1056	945	1275	1205	1026
1104	1059	946	1279	1208	1028
1106	1061	948	1282	1210	1029
1109	1063	949	1285	1213	1030
1111	1065	950	1289	1216	1031
1114	1068	952	1292	1219	1032
1116	1070	953	1295	1221	1034
1119	1072	954	1299	1224	1035
1121	1074	956	1302	1227	1036
1124	1076	957	1305	1230	1038
1126	1078	958	1308	1233	1039
1129	1080	960	1312	1236	1040
1131	1082	961	1316	1239	1041
1134	1085	962	1319	1242	1042
1136	1087	964	1323	1245	1043
1139	1089	965	1326	1247	1044

GEO. G. ANDRÉ.

VELOCITY AND RECOIL.

(*Field*, Nov. 25, 1899; Vol. 94, p. 850.)

IN our issue of Dec. 31, 1898, we published a letter and foot-note on the above subject, which we now reproduce:

SIR,—I always thought that recoil depended entirely upon velocity, *i.e.*, that a high velocity meant a high recoil, and that when a low velocity was registered a reduction in force, or velocity, was observable. I have been carefully reading a large number of trials published in the *Field* of various nitro powders, and it somewhat puzzles me to find that, in many instances, where the powders have given your standard velocity of about 1160ft., there should be such great differences registered in recoil.

I have been equally puzzled over my own observations when shooting. To take one example, I may mention the new powder which the E.C. Powder Company have issued called, I believe, E.C. No. 3. This powder, according to your trials, gave the standard velocity, and I know from my own experience that it is wonderfully hard hitting. Yet the recoil seems to be

very much less than all the nitros I have tried, and I have tried the best of them, both in a heavy day's shooting and according to your trials. Can you help me, sir, to solve the riddle? MERIVALE.
Brighton.

[A high velocity certainly means a high recoil, but the weight and velocity of the shot must not alone be taken into consideration. There are the wads, and what is of far more importance, the weight and velocity of the gaseous products of combustion. With any given gun, shot charge, and velocity, the energy of recoil generally varies with the weight of powder used. It follows, therefore, that powders of the concentrated type give less recoil than those of a less potent nature. The space in the cartridge occupied by the powder has also some influence on the relation between velocity and recoil. We hope soon to be in a position to give our correspondent and others interested more exact information on the subject than we hitherto have been able to do; that is to say, when our new range, fitted with a Smith chronograph and recently designed recoil machine, is completed.—ED.]

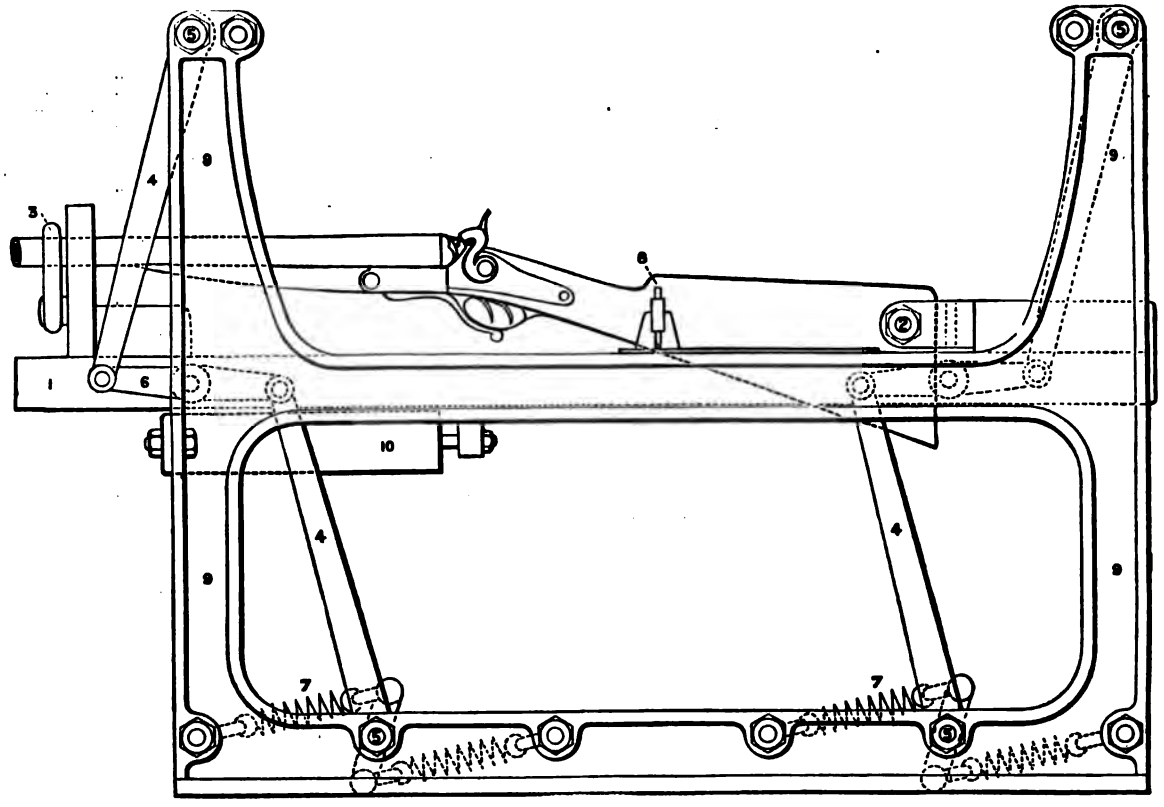


FIG. 1.

has therefore disconnected, and a ratchet and pawl, which was practically frictionless, fitted in its place. It was next found impossible to obtain a uniform turning effort upon the shafts (5) by means of the levers and spiral springs (7). The mechanical device shown in Fig. 2 was therefore designed: 1 is a peculiarly shaped double cam fixed upon the shafts, marked 5 in Fig. 1. The spiral springs transmit their pull to the cams through an extremely thin tempered steel band (2). By means of this simple arrangement an absolutely uniform force is transmitted to the recoiling table and gun, notwithstanding the increased tension of the spiral springs as they become elongated with the recoil of the gun.

Upon commencing work with our new Smith chronograph we soon discovered a very serious defect. The travelling frame of the instrument to which the smoked glass plate is clamped had to be cocked against the force of a strong mainspring by hand. This could not be done without unduly stressing the axles of the wheels and their connections, and occasionally in the middle of a set of trials the travelling frame would leave the rails altogether, causing loss of time and annoyance, and endangering the more delicate parts of the instrument. We therefore devised the apparatus shown in Fig. 3: 1

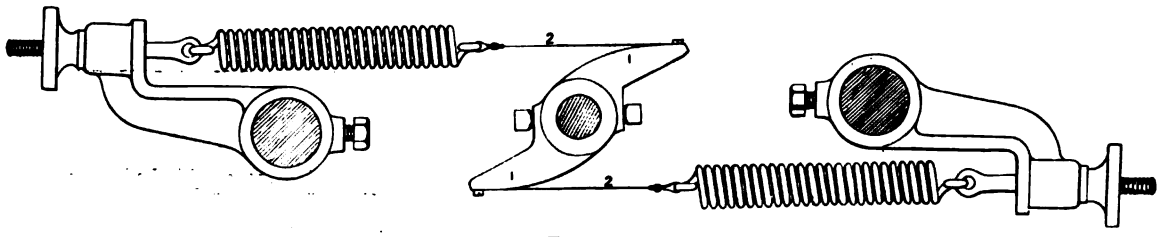


FIG. 2.

In the first place we must apologise to our correspondent for the length of time taken in fulfilling our promise, but we have had many difficulties to contend with. Upon testing our new gun-rest and recoil gauge it was found that the pneumatic buffer (10) (Fig. 1), although very convenient for ordinary work, caused a small amount of friction which was inadmissible when very accurate results were desired. It

is the spring to be compressed; 2 is a bracket fixed to the foundation of the instrument which carries the hand and foot lever (3); 4 is a forked catch or grapnel. By engaging the catch or grapnel with the mainspring rod, a slight pull with the hand at 3, combined with a pressure of the foot at 5, is sufficient to compress the mainspring, without the slightest risk of damaging the delicate parts of the instrument. In the Smith chronograph the time line is produced by the vibrations of a tuning fork. It is the practice to produce these

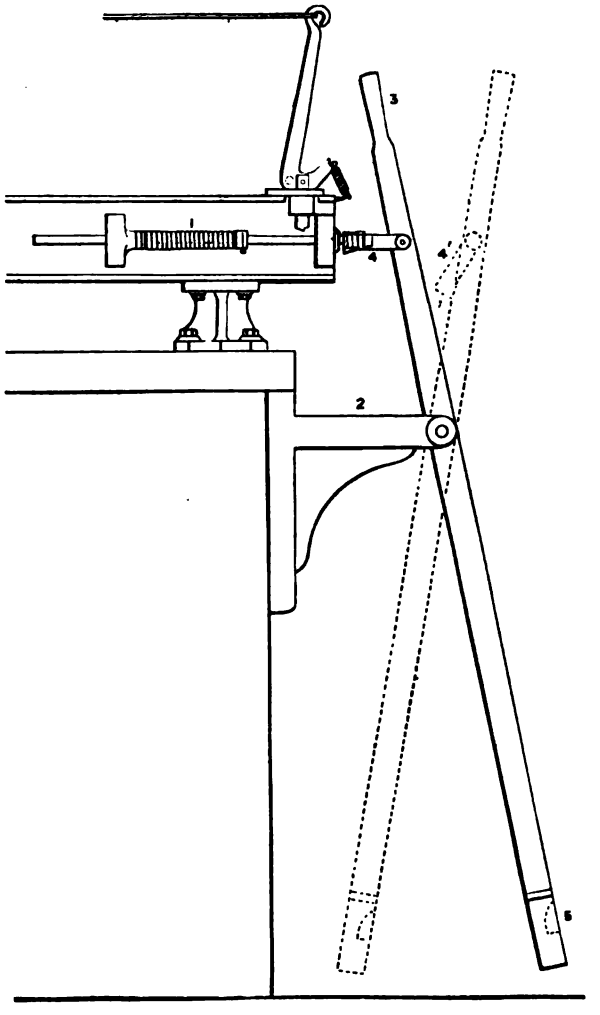


Fig. 3.

vibrations by striking the fork with a small mallet held in the hand. But this is a very uncertain arrangement, because if the blow is not of proper strength the undulations of the time line are not sufficiently distinct; on the other hand, if the blow is too violent a stylus may be jarred down and a record lost. We therefore devised the arrangement shown in Fig. 4: 1 is a foreshortened view of the tuning fork; 2 is the mallet rocking on a spring-wound fulcrum (4). The trigger cord (5) is connected with the main trigger cord for releasing the travelling carriage. The action is as follows: Upon pulling the main trigger cord, the trigger (3), as well as the main trigger, is actuated, and the mallet falls, striking the fork, and also the rebound spring (6); it is then thrown up into the position shown by the dotted lines, and is held there by the automatically working detent (7 and 8). If it were not held up in this way the mallet would be broken by the travelling frame coming into collision with it.

For the present trials we chose powders as widely different as possible from each other, namely, Schultze, E.C. No. 3, Ballistite, and C. and H. No. 2 T.S. The results are given in tabular form, and it will be noticed that the energy of recoil in proportion to the energy of the shot charge is least in the case of E.C. No. 3, closely followed by Ballistite; in fact, from a practical point of view these two powders may be considered equal in this respect. With regard to regularity, the black powder heads the list, there being only 45ft.sec. difference between the highest and lowest records. Ballistite comes next, with a difference of 76ft.sec., followed by E.C., with a difference of 97ft.sec., and Schultze, with a difference of 110ft.sec.

In order to ensure the greatest possible accuracy, every charge of powder and shot was carefully weighed and the wadding selected. The same gun was used throughout the trials, and was fired at a rigid steel plate 1in. in thickness. The electric current was broken by the vibrations caused by the impact of the shot, passing through the plate and actuating a contact-breaker fixed at the back.

The mean velocities in a range of ten yards were first ascertained, and from that data the muzzle velocities were determined by means of the excellent tables compiled by Mr Geo. G. André (*Field*, April 1, 1899).

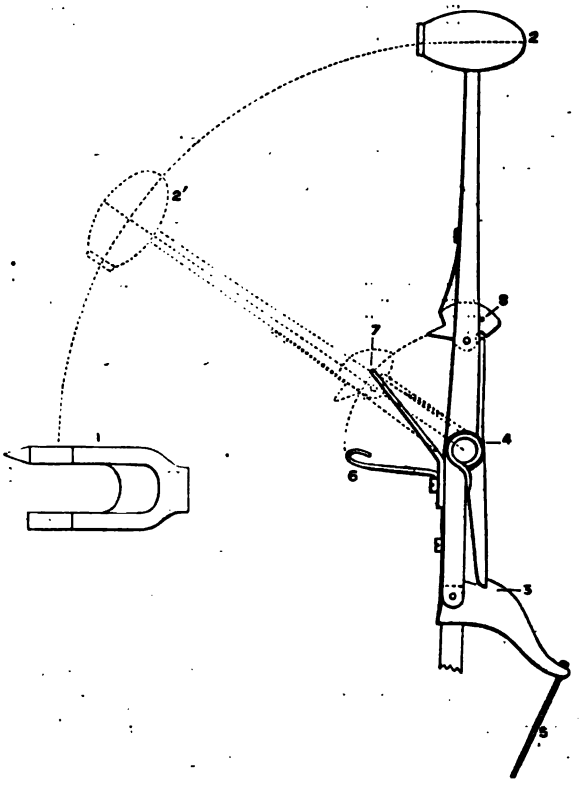


Fig. 4.

Barometer, 29·75; thermometer—wet, 58°; dry, 60°. 12-bore gun; weight, 7lb.; barrels, 30in. Wadding—$\frac{1}{2}$in. card, $\frac{3}{8}$in. felt, $\frac{1}{2}$in. card; thin card over shot.

38grs. of E.C. No. 3, 1$\frac{1}{8}$oz. No. 6 shot (304 pellets).

Muzzle velocity. Ft.sec.	Recoil. Ft.lb.	Muzzle velocity. Ft.sec.	Recoil. Ft.lb.
1214	28·2	1142	25·5
1189	26·5	1127	24·6
1179	25·8	1127	25·1
1169	25·8	1113	24·3
1165	25·9	1117	24·3
1165	25·5	—	—
1142	24·9	Average 1154	Average 25·5

Energy of shot at muzzle, 1448ft.lb. Ratio of energy of shot at muzzle to energy of recoil, 56·78 to 1.

Barometer, 29·61; thermometer—wet, 59°; dry, 61°. 12-bore gun; weight, 7lb.; barrels, 30in. Wadding—$\frac{1}{2}$in. card, $\frac{3}{8}$in. felt, $\frac{1}{2}$in. card; thin card over shot.

27grs. of Ballistite, 1$\frac{1}{8}$oz. No. 6 shot (304 pellets).

Muzzle velocity. Ft.sec.	Recoil. Ft.lb.	Muzzle velocity. Ft.sec.	Recoil. Ft.lb.
1231	28·1	1183	27·1
1225	28·0	1182	26·5
1209	28·2	1165	27·0
1208	28·0	1165	26·1
1199	28·2	1155	26·8
1189	27·0		
1189	27·6	Average 1192	Average 27·4

Energy of shot at muzzle, 1544ft.lb. Ratio of energy of shot at muzzle to energy of recoil, 56·35 to 1.

Barometer, 29·60; thermometer—wet, 59°; dry, 60°. 12-bore gun; weight, 7lb.; barrels, 30in. Wadding—$\frac{1}{2}$in. card, $\frac{3}{8}$in. felt, $\frac{1}{2}$in. card; thin card over shot.

42grs. of Schultze, 1$\frac{1}{8}$oz. No. 6 shot (304 pellets).

Muzzle velocity. Ft.sec.	Recoil. Ft.lb.	Muzzle velocity. Ft.sec.	Recoil. Ft.lb.
1208	30·2	1152	26·9
1194	29·6	1147	27·0
1194	29·7	1137	26·0
1188	28·9	1115	26·1
1184	28·2	1093	25·0
1184	28·5		
1170	28·1	Average 1163	Average 27·8

Energy of shot at muzzle, 1470ft.lb. Ratio of energy of shot at muzzle to energy of recoil, 52·38 to 1.

Barometer, 29·58; thermometer—wet, 60°; dry, 61°. 12-bore gun; weight, 7lb.; barrels, 30in. Wadding—$\frac{1}{2}$in. card, $\frac{3}{8}$in. felt, $\frac{1}{2}$in. card; thin card over shot.

70grs. of C. and H. No. 2 T.S., 1$\frac{1}{8}$oz. of No. 6 shot (304 pellets).

Muzzle velocity. Ft.sec.	Recoil. Ft.lb.	Muzzle velocity. Ft.sec.	Recoil. Ft.lb.
1208	32·6	1165	30·8
1183	32·1	1165	31·0
1179	31·6	1165	31·2
1179	31·4	1165	31·3
1170	31·8	1163	31·0
1168	31·3		
1168	31·7	Average 1173	Average 31·5

Energy of shot at muzzle, 1496 ft.lb. Ratio of energy of shot at muzzle to energy of recoil, 47·49 to 1.

SHOT RATTLING IN CARTRIDGES.

(*Field*, Feb. 6, 1892; Vol. 79, p. 165.)

A FEW weeks ago a correspondent inquired whether the shooting qualities of cartridges would be affected by the shot becoming so loose as to rattle in the cases. That it frequently will rattle after cartridges have been much shaken—as in long railway journeys, or by being carried about by sportsman or attendant during a long day's shooting—is a fact which is pretty generally known; but, so far as we are aware, little definite information is forthcoming as to the effect on the killing powers of the cartridges. We have therefore carried out a few experiments, to learn what the facts really are, and especially to ascertain whether cartridges loaded with nitro powder are more affected than those loaded with black powder, as seemed likely to be the case.

We accordingly loaded half a dozen cartridges with Schultze, and a similar number with No. 4 black powder (charge, 3drs. and 1$\frac{1}{8}$oz. No. 6). In half of the cartridges the cases were turned over rather tightly, though not excessively so; the other half were not turned over quite so tightly, and, before being fired, they were bumped and shaken about until the shot rattled very freely. The cartridges were then tried at the target, and the mean velocities for the 40 yards were taken by chronograph. The records were as follows:

	Mean velocities.			Averages.
C. & H. No. 4.—With tight shot	831	829	828	= 829 ft.sec.
,, ,, ,, loose shot	808	808	809	= 808 ,,
Reduction of velocity				21
Schultze.—With tight shot	868	867	870	= 868 ,,
,, ,, loose shot	770	772	774	= 772 ,,
Reduction of velocity				96

It will be observed that there was a reduction of velocity with both powders, when the shot was loose; but the diminished resistance, consequent on the looseness of the charge, told much more seriously on the nitro-compound than on the black explosive, so far as regards the velocity of the shot. The pattern, however, was greatly improved. With a choke-bored gun the number of pellets placed in the 30in. circle was increased by about thirty, with Schultze powder, and their distribution was beautifully regular—far more so than in the case of the tight charge—a fact which is in accord with the general experience, that greater propulsive force in the powder is usually accompanied by greater scattering of the shot. With black powder the results were somewhat similar in character, though not to so marked an extent as with the nitro-compound.

VERTICAL PENETRATION.

(*Field*, Dec. 18, 1897; Vol. 90, p. 980.)

SIR,—As many experienced shots are under the impression that pheasants 40 yards high are out of the killing range of ordinary sporting guns, I have carried out the experiment as detailed below, with a view to ascertaining whether any difference in penetration of shot fired vertically, as against the same fired horizontally, does exist.

I had some difficulty in finding a suitable elevation, but Mr Alfred Richards came to my rescue, and, through his neighbour, Mr Neive, obtained for me access to one of the highest windmills in Norfolk. I have also to thank Mr Moore, who, in the interest of sport, stopped his mill for nearly a whole day.

The sketch herewith will illustrate how the trial was conducted:

PENETRATION CARD RACK ATTACHED TO SAIL OF WINDMILL.

The box hanging from the top of the poles lashed to the uppermost sail was exactly 120ft. from the ground—the measure being taken with a plumb line suspended from it, which also guided my aim. The said box had an aperture at its bottom end of 8in. by 3in., which was filled by a strawboard, and succeeding ones continued every ¾in. up to twenty-four.

Five shots were fired and the result noted, and then the box was lowered and placed 40 measured yards distant to receive five horizontal shots. The results were as follows:

Vertical Test.		Horizontal Test.	
Pellets through	18 strawboards ... 1	Pellets through	22 strawboards ... 1
" "	17 " ... 2	" "	18 " ... 1
" "	15 " ... 10	" "	17 " ... 3
" "	14 " ... 5	" "	16 " ... 2
" "	13 " ... 5	" "	15 " ... 5
" "	12 " ... 2	" "	14 " ... 6
" "	11 " ... 1	" "	13 " ... 4
Average penetration, 14·31.		" "	12 " ... 2
		" "	11 " ... 3
		" "	10 " ... 1
		Average penetration, 14·46.	

The right barrel of a good 12-bore was used, which makes a pattern of about 140, and the load was 42grs. Schultze and 1⅛oz. No. 6 Walker's hard shot.

The shooting was very even, the five shots of each series producing nearly an equal number of hits (viz., 26 pellets in the vertical rounds, and 28 in the horizontal). On referring to the figures it will be seen that the bulk of the pellets stopped after penetrating 13, 14, and 15 cards, and the average result is practically the same in each case.

A very aged and noted wildfowler of the Broads witnessed the trial, and he was confident the vertical penetration would be weak, from the observations he had made in large numbers of practical experiments on fowl with his long single muzzle-loader by Egg.

This experience points to the fact that birds overhead appear nearer than they really are; or, if this is not so, the difficulties of judging where and how to fire in front are intensified at this angle.

W. W. Watts (Managing Director).

London Sporting Park, Hendon, N.W.

[Mr Watts's experiments, as described above, appear to us to thoroughly confirm the theoretical conclusions on this subject—viz., that there would be no practical difference in the penetration of the shot at the height of 40 yards, from that given at the same distance when fired horizontally. Theoretically there would be a slight amount of difference, owing to the "gravity pull;" but the time of the shot in traversing 40 yards is only about one-seventh of a second, and in that interval of time the influence of gravity would lessen the height of the shot by the 49th part of 16 feet—*i.e.*, about four inches; so that firing vertically at a target placed at the height of 40 yards would be equivalent to firing horizontally at one placed at a distance of 40 yards 4 inches.—Ed.]

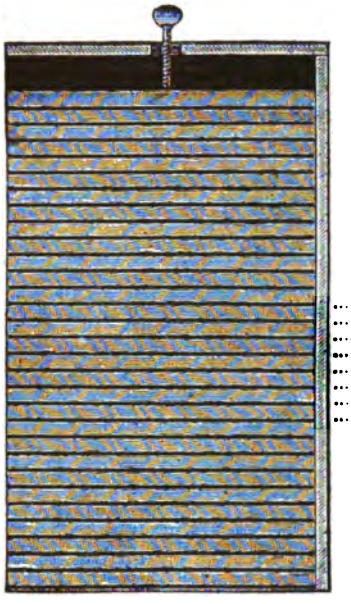
(*Field*, Dec. 22, 1898; Vol. 91, p. 126.)

Sir,—I am much interested in Mr Watts's experiments on "vertical penetration" of a shot gun in your edition of Dec. 18. It is not, however, quite clear, I think, from Mr Watts's explanation, how he arrived at the penetration; though I have no doubt it is easily explainable by him. *E.g.*, how do ten pellets in the vertical test penetrate fifteen strawboards, and only five pellets fourteen boards. The test reads as if the ten pellets which penetrated the fifteen boards should first have gone through the fourteen boards and penetrated them, as well as all the boards up to fifteen. When this is explained it will make matters clearer.

With regard to your own remarks I should be very much obliged if you would say what the muzzle velocity of the shot is from such a gun and cartridge and loading as mentioned. I presume you must know this as you make the "gravity pull" equivalent to 4in. in 40 yards. If one knew the muzzle velocity of an ordinary charge it would be easy to work out the gravity pull at any distance vertically up to the point of rest. I shall therefore be much obliged if you will inform me what it is, for if the penetration is for all practical purposes the same vertically as horizontally, as you show, I cannot understand why our good shots so often miss high pheasants, though very few ever see them at 40 yards vertical, I imagine. To my idea, 30 yards is a very high bird.

W. B. Thornton.

[The following illustration of a "card-rack" may serve to render the explanation more clear, although the rack here represented may possibly not be of exactly the same make as the one that was used by Mr Watts. Ordinarily the rack is placed in a horizontal position, with the strawboard cards standing upright; but in these experiments the rack was suspended vertically from the sail of a windmill, with the cards lying horizontally, as shown in the illustration. The height of the rack was 120 feet from the ground, and the cards were three-quarters of an inch apart.



Number of Cards.		Number of Pellets.		Perforations.
..... 18	×	1	=	18
..... 17	×	2	=	34
..... 16	×	0	=	—
..... 15	×	10	=	150
..... 14	×	5	=	70
..... 13	×	5	=	65
..... 12	×	2	=	24
..... 11	×	1	=	11
Total,		26	=	372

Suspended Card Rack.

Alongside the rack we give figures showing the numerical order of the cards penetrated, together with the number of pellets that passed through the respective cards, as stated by Mr Watts. But it need hardly be stated that if a pellet passed through the eighteenth card, it must also have passed through the previous seventeen. The size of the aperture (here not visible) was stated by Mr Watts to be 8in. by 3in., or 24 square inches; and within that space were 26 pellets, the whole of which passed through 10 strawboards before any of the pellets came to a standstill. From cards 11 to 18, the number of pellets that penetrated the respective cards were as stated alongside the card-rack. Taking them all together, the 26 pellets made 372 perforations in the various cards, or an average of rather more than 14¼ cards per pellet. In the horizontal test, 28 pellets struck the rack, and the average number of cards penetrated was rather under 14½ per pellet; so that the difference between the two would be inappreciable.

As regards the "muzzle velocity," it would, with the charge used, be about 1200 feet per second; but the extent of the "gravity pull" could not be estimated from this alone, owing to the subsequent loss of speed in the pellets from atmospheric resistance. It could be readily calculated, however, from the "mean velocity," when known; but this would vary with the distance and the size of the pellets. Thus, with No. 6 shot, the mean velocity in 30 yards would be about 920 ft sec., whereas in 40 yards the mean velocity would be about 840 ft.sec.

In our opinion, the reason why so many men miss "high pheasants" is the comparative difficulty in alignment of the gun, and not any appreciable diminution in velocity of the shot. The angle between the eye, the muzzle, and the bird, when the gun is nearly horizontal, is very different from what it must be when the barrel is nearly vertical; besides which, the physical conformation of the neck and shoulders of some men would make it very difficult for them to give so ready an allowance as others could do on the spur of the moment. —Ed.]

NITRO POWDERS IN WILDFOWL GUNS.

(*Field*, Dec. 23, 1899; Vol. 94, p. 974.)

KYNOCH SMOKELESS IN 8-BORES.

Some wildfowlers have long memories, and they doubtless will readily recall the words of "20,000 Shots," who some time ago, whilst, as usual, freely drawing upon a lifetime's experience in matters connected with guns and gunnery, had occasion to allude to the difference in the behaviour of the same powder in large and small bores. That such variation does exist is patent to all who have experimented much with guns of different calibre. It therefore does not of necessity follow that, because the explosive named above has been found to give good results in long-case 12-bores, shooting equally good would be attained to by its use in 8-bores and 4-bores—which, truly, are duck guns. Consistently, therefore, with my researches in respect of the behaviour of all the other bulk nitro powders, they in turn having been tried in 8-bores and 4-bores, I have this season been pursuing these experiments in the direction of determining as to what are suitable charges of Kynoch Smokeless to employ in the larger-bored shoulder duck guns.

I will now give the results of some target experiments obtained with ammunition of two distinct kinds, viz., paper and brass cases.

The gun used for the trial of the powder in paper cases was a single-barrelled 8-bore, by Chas. Boswell, weighing 12lb. For the trial of the powder in the thin brass "Perfect" cases a double 8-bore, by Messrs Reilly and Co., Oxford-street, designed for the use of paper or brass cases, was employed. Neither gun is remarkable for the amount of choking given to the barrels, each being designed to be of some service at both long and short ranges. In the

Paper-case Trial

the loads were as follows: "Perfectly Gastight" cases, 3¼in. long, powder 80grs. of Kynoch smokeless; wadding, one waterproof, one felt ⅛in., one thin card on powder; 2¼oz. No. 1 shot, counting 9¼ pellets to the ounce, the complete charge totalling 212 pellets; a stout card on the shot, and good turnover of about ¼in. The fine targets of the London Sporting Park Company, at Hendon, were used for most of the following trials. As will be noticed, the diameter of the circle within which patterns were counted was, in every instance, 30in.; the length of range varying from 40 yards to 60 yards. The single-barrelled gun gave the following

Patterns.

40 yards.		60 yards.
117		61
121		57
108		49
124		65
103		70
112		52
685		354
114 average.		59 average.

Penetration.

40 yards.

Pellets.		Sheets.
1	through	21
1	"	27
1	"	28
1	"	29
1	"	31
5 hits,		5) 136 perforations.
Average number of sheets pierced.....		27⅕
Highest number pierced by one pellet...		31

60 Yards.

Pellets.		Sheets.
1	through	29
2	"	25
1	"	18
4 hits.		97 perforations.
Average number of sheets pierced.....		24¼
Highest number pierced by one pellet...		29

The foregoing are not of course remarkably close patterns, but, being evenly distributed on the plate, they are found to answer well at average distances, and for many situations, both afloat and ashore, in the daytime.

With the same gun, cartridge case, wadding, and powder charge as the foregoing, but with 2⅛oz. of BB., counting fifty-five pellets to the ounce, the following results were obtained:

Patterns.

40 yards.	60 yards.
87	42
84	37
79	28
88	43
81	33
77	38
496	221
82 average.	36 average.

Penetration.

At 40 yards distance the driving power of the powder and the weight of the pellets proved invincible, for, with but few exceptions, the whole of the 31 sheets of stout strawboard in the Watts shot penetration rack were perforated. The two or three exceptions noted were those in which some more than usually battered pellet failed to keep up with the rest.

60 yards.

Pellets.		Sheets.
2	through	31
1	"	30
1	"	28
4 hits.		120 perforations.
Average number of sheets pierced		30
Highest number pierced by two pellets...		31

It will be noted that even at this range half the pellets got through the whole of the sheets.

Brass-case Trial.

The loads used in the Reilly double 8-bore were as follows: Thin brass "Perfect" cases 3¼in. long; powder, 92grs. of Kynoch Smokeless; wadding, one waterproof, one ⅛in. felt, one stout card; shot, 2½oz. No. 1, counting 94 pellets per ounce, total charge 235 pellets; overshot wad, stout card, the case having a solid good crimp of fully ¼in.

Patterns.

40 yards.

Left Barrel.	Right Barrel.
124	97
152	118
137	120
160	111
119	101
129	116
821	663
136 average.	110 average.

60 yards.

Left Barrel.	Right Barrel.
57	48
64	49
60	59
68	77
53	60
58	51
359	344
59 average.	57 average.

Penetration.—40 Yards.

Pellets.		Sheets.
2	through	31
2	"	29
1	"	24
1	"	19
6 hits.		163 perforations.
Average number of sheets pierced		27⅕
Highest number pierced by two pellets		31

60 Yards.

Pellets.		Sheets.
1	through	31
1	"	29
1	"	33
1	"	15
4 hits.		98 perforations.
Average number of sheets pierced		24½
Highest number pierced by one pellet...		31

The same gun—*i.e.*, the double Reilly 8-bore—"Perfect" cases,

wadding and powder charge as used in the foregoing, but 2¼oz. B.B., counting fifty-six pellets per ounce, gave the following results:

Patterns. 40 yards. Left Barrel.	Right Barrel.	Patterns. 60 yards. Left Barrel.	Right Barrel.
81	74	38	35
77	70	42	39
85	87	51	39
94	79	40	47
88	89	52	31
90	89	48	37
515	488	271	228
85 average.	81 average.	45 average.	38 average.

Penetration.—40 Yards.

Here an average of five pellets struck the rack, all practically going through the thirty-one sheets of strawboard.

60 Yards.

Pellets.		Sheets.
4	through	31
1	"	29
5 hits.		153 perforations.
Average number of sheets pierced.....		30
Highest number pierced by four pellets		31

As already remarked, the foregoing patterns are not the closest obtainable. But, of course, close shooting is much a question of degree in choking; given the requisite amount and form of choke, any number of pellets up to a certain point may be placed on a target. Still, whatever exception any hankerer after extremely close patterns may make as to the foregoing, none whatever could be taken with respect to the distribution of the pellets over the surface of the targets; in this particular guns and ammunition acquitted themselves admirably. Many considerations have to be weighed up in wildfowling; thus, whilst closer shooting might easily have been obtained by altering the proportion of powder to shot, yet, all considered, such extra close shooting is not at all times desirable. For the successful pursuit of wildfowl in the daytime, and for all tough birds, such as grey geese, brents, mallard, scaup, pochard, wigeon, and the like, a high velocity must be imparted to the shot. When sailing to fowl in daylight, shooting at long ranges must perforce be undertaken. Thus, while trying to secure fairly close shooting guns for such purpose it will be expedient—unless, indeed, guns of various degrees of choking are used for the different phases of sport—to secure the mean of advantages by balancing the pattern and penetration of the shot pellets as fairly as may be. Evenness of distribution of the pellets is one of the most important factors conducing to success in shooting, and to secure this the gunner may sacrifice much that has been thought by some shooters to be of first importance. Even the velocity of the pellets sinks into comparative insignificance beside their trueness of flight, for, after all, what matters it if they are doubly speedy provided they do not fly true and straight?

As supplementary to the foregoing, the following results of a trial of paper cases in the Reilly double 8-bore may possibly be of service. These figures go to prove two things: First, that reliable shooting may be obtained out of one gun with both paper and brass cases; and, second, that the explosive under trial, *i.e.*, Kynoch Smokeless, maintained its position with regard to regularity of results obtained in respect of pattern and penetrative force when put through this somewhat exacting ordeal. With paper cases and charge of No. 1 shot as before in Reilly gun:

Patterns. 40 yards. Left Barrel.	Right Barrel.	Patterns. 60 yards. Left Barrel.	Right Barrel.
115	117	50	50
130	98	62	44
110	121	77	55
124	108	63	62
120	112	51	51
118	101	69	47
717	657	372	309
119 average.	109 average.	62 average.	51 average.

Penetration.

The former trials having clearly determined the penetrative force of the pellets at 40 yards to be sufficient for any fowl, however large and tough, met with by the wildfowler, this test was taken at the longer range only.

60 Yards.

Pellets.		Sheets.
1	through	30
1	"	28
1	"	21
3 hits.		79 perforations.
Average number of sheets pierced		26
Highest number pierced by one pellet ...		30

With the larger size of shot, BB, the results were as follow:

Patterns. 40 yards. Left Barrel.	Right Barrel.	Patterns. 60 yards. Left Barrel.	Right Barrel.
74	68	26	25
77	80	35	28
83	76	29	39
70	76	41	36
79	71	39	33
89	79	40	38
472	450	210	199
78 average.	75 average.	35 average.	33 average.

Penetration.—60 Yards.

Pellets.		Sheets.
4	through	31
1	"	27
5		151 perforations.
Average number of sheets pierced		30
Highest number pierced by four pellets...		31

I have always attached considerable importance to the use of the card rack in such tests as the foregoing, for the simple reason that it affords us a ready means of testing the force of the pellets at killing ranges, whilst affording also direct and convincing evidence as to the condition of the pellets at the end of the journey. I have emphasised the words "at killing ranges" for the simple reason that thus to ascertain the penetrative force of pellets is a matter of considerable importance to the wildfowler. There are, I am aware objections to be urged against the card rack; still, I think it cannot be denied that it is at present the most reliable instrument that we have for the purpose above indicated. It certainly is simpler to work, the results are clearly to be seen, and, provided due care is exercised in procuring strawboard sheets of uniform weight, texture, and dryness, the records obtained are sufficiently reliable for all practical purposes so far as the sportsman is concerned. One drawback with respect to chronographic records is that the pellet velocities recorded are taken at the commencement of the flight of a charge of shot. Certainly, we cannot very well dispense with records so taken, but to be complete velocities should, I submit, also be taken at killing ranges. If means could be devised for accurately determining the speed of flight of pellets at the usual distances at which guns are used upon game and wildfowl (say, from 30 yards to 100 yards), much valuable data might be acquired with respect to the driving power of a powder and the flight and relative value of the different sizes of shot.

Henry Sharp.

(*Field*, Dec. 30, 1899; Vol. 94, p. 998.)

KYNOCH SMOKELESS IN 8-BORES.

In two important respects the trial of this nitro-compound has so far proved eminently satisfactory. First, there is a total absence of hang fires to record; and secondly, this powder displays in remarkable degree the ability to produce regular results at the target, in respect both of evenness of distribution of the shot pellets and their striking energy.

Indisputably, the interests of sportsmen are best served by that manufacturer of sporting powder who puts them in possession of an explosive in which all good and desirable qualities are nicely and scientifically balanced. In the history of modern smokeless powders it has, from time to time, been clearly demonstrated that the inordinate subordination of one good property to another invariably leads to disaster. For instance, the attempt to gain an advantage in respect of an increase of velocity by rendering more rapid the combustion of the powder usually puts a strain upon the gunbarrel greatly in excess of that exerted by safe working pressures. Even if the

question of danger is eliminated, and it is conceded that such high pressures are permissible, it is undeniable that the undue quickening of combustion will greatly increase the shock of recoil, and so add enormously to the gunner's discomfort.

Some five years ago, when I commenced publishing the results of my trials of nitro powders in shoulder duck guns, that great bugbear of all gunners, hang fire, was unpleasantly rife. It is not too much to say that nothing would more quickly or effectually relegate all big shoulder guns to the limbo of disuse than the frequent occurrence of hang fires. Certainly, I know nothing more calculated to upset the gunner's equilibrium, literally and figuratively, than the frequent recurrence of such troubles. A misfire may, and undoubtedly does, give the shooter a few seconds of most trying suspense; but a hang fire, however careful he may be, often catches him unawares, knocks him all acock, and shatters both nerves and temper completely, if, indeed, nothing worse happens. The bad hang fires I had to contend with in some of my early experiments with nitro powders in 8-bores and 4-bores are certainly to be reckoned amongst the most trying of my gunnery reminiscences. Mishaps of the sort effectually upset the peace of mind of even the most hardened gunner, rendering him distrustful; then, with confidence in his weapon gone, good-bye to all success in sport. But, beyond the mere question of nerve and mind trouble engendered by a hang fire, there is real physical danger, and, unless on hearing the snap of the hammer the first natural impulse to lower the gun and tendency to relax the grasp be checked, a heavy blow will be received. Knowing this, I record with all the greater satisfaction the fact that with Kynoch Smokeless there has been in the course of my trials an absolute immunity from hang and miss fires—this with guns by several different makers, and using both paper and brass cases.

Next, with respect to regularity of results, it may be as well to remark that my trials are fairly thorough and severe, that is, from the sportsman's standpoint. Most shooters, wildfowlers especially, subject their cartridges to most trying tests at times. Cartridges are carried about for hours in a belt exposed to the fierce rays of a tropical sun, or it may be for days in an atmosphere reeking with moisture; or, again, cartridges may be left, with no more protection than that afforded by a canvas bag, on the yacht's deck whilst the thermometer registers ten or more degrees of frost. Having this in my mind, freshly loaded cartridges have been shot in the course of these trials side by side with others that have been exposed most fully to many changes of temperature and atmospheric variation. Short of actual exposure to rain or snow, no cartridges could well have undergone severer trial than have those last mentioned, left open as they were to the air in a situation where fog and damp, heavy frost and heat, had unrestricted play upon them. As a matter of fact, some of the results given in the tables published in my article of last week were obtained from these weathered cartridges. The figures go to show that, despite their exposure, the shooting of these cartridges was not appreciably impaired.

The trials conducted under the above heading are, purely and simply, the practical sportsman's test of such nitro powders as are brought to my notice. The present trial, as in the case of the other bulk nitros, may be divided into two clearly defined sections, the first comprising the target tests, and the second a thorough trial on flood and field—that is to say, the actual shooting of wildfowl under the ordinary conditions of weather and sport. It is gratifying to discover that these trials are more than serving the purpose for which they were originally intended. Whilst primarily designed to be of service to the sportsman by assisting him to avail himself of many advantages conferred by the use of a nitro powder in heavy shoulder guns, proof has lately been afforded that good may result in another direction, viz., the practical adaptation and embodiment, in the building of new guns, of the ideas evolved from, as well also the experiences gained by, the constant use of nitro powders in duck guns. Some little time ago I was the recipient of a request made by one of our oldest and best-known gunmaking firms to draw up specifications for the building of duck guns for use with smokeless powder on the lines suggested by a lengthy experience of the employment of nitro powders in heavy shoulder guns. The specifications as drawn up involve some most radical changes in the construction of this class of sporting arm. Whether guns so constructed will prove entirely successful time and trial alone will prove. In any case it is to be anticipated that an advance will have been made in respect of the modernisation of the altogether too cumbrous and antiquated duck gun of the day; and, further, that the firm bold enough to carry out such changes will earn the lasting gratitude of modern wildfowlers.

The 8-bore target trials having satisfactorily determined that the Kynoch smokeless is a stable and regular-shooting powder, the next step, in accordance with the scheme of trial as outlined above, was to put it to actual test in the field. I therefore, one bitterly cold afternoon some few days ago, found myself well out upon a wide reach of saltings at a certain point on our east coast. Even to the enthusiastic wildfowler the picture spread before me presented one vast scene of dreariest desolation. North and south the dull brown of ooze and aquatic herbage stretched for miles, whilst seawards the hazy atmosphere merged land and water into one harmonious whole, so that it was impossible to tell precisely where one ended and the other began. Still, dreary as was the outlook, one touch of animated nature was all that was required to transform the position into, if not exactly a paradise, at least a most desirable spot for the location of those who, like myself, might be on wildfowling bent.

This most desirable change was not long in coming, for shortly after I had seated myself on an old tide-washed hamper in the bottom of a creek some curlews were astir. These wariest of fowl were coasting along by the edge of the green shore, and although their presence and wild call notes were distinctly cheering as enlivening and brightening up the scene, there was nothing just at that time to be done in the way of shooting, as the birds invariably passed just out of gunshot.

The gun I had taken on this occasion, a double 8-bore by Messrs Reilly, was exceptionally powerful, and as, moreover, I had cartridges containing very heavy charges of both powder and shot—to be precise, 90grs. of Kynoch smokeless and 2¼oz. of No. 1—I decided to take every chance offering in which appeared the slightest possibility of bringing down a bird. The first attempt of the sort proved entirely successful. The shot was taken at a single curlew that was of a certainty not less than 80 yards distant. Flying at a good height, the bird offered a clear mark in the grey light; had it been otherwise it perhaps might not have been fired at. It was moving at a rare pace, so swinging the gun well ahead I let drive, and had the satisfaction to see the curlew come down headlong. Anxious to determine as to the result of the shot before the light got worse, I left my hiding place a few minutes later, and proceeded to pace the distance as well as I was able. This proved a somewhat difficult matter, seeing that no fewer than three fair-sized rivulets lay in my path. However, in the end I was completely satisfied that if chain or tape measure had been handy the distance would have proved to be something over 80 yards. This was very satisfactory, and the more so as it was clear that the bird had been killed instantly, for in addition to one pellet right through the head, which, of course, in itself would have sufficed, I found another pellet deeply implanted in the body, and this, too, by reason of its position in the region of heart and lungs, as well by the bleeding it had set up, must of itself have quickly proved fatal.

The next shot fired, also at a single bird, was not so successful. This time an oystercatcher claimed attention, but, moving at double quick speed low down over the mud, the bird fairly beat me, the two barrels fired having apparently no other effect than to increase its speed. Conspicuous enough when in hand, or at a distance in a strong light, or with the sun shining on it, the strongly contrasted black and white plumage of the oystercatcher is nevertheless not so readily discerned in the murky gloom of a short December afternoon. Consequently, as the bird was not more than sixty yards away, I felt that neither gun nor ammunition could be blamed for the failure.

More curlews came along shortly after the oystercatcher discomfiture, all of them, however, keeping at a most discreet distance from the greenshore. Luckily my period of idleness did not continue long, for earlier than their wont—that is to say, by the clock—the ducks began to fly. I soon discovered the approach of a small bunch of duck. There were three in this little lot, and in the knowledge that the gun in use was powerful, the shot large, and the charge heavy, a departure was made from the generally recognised tactics of the wildfowl shooter—that is to say, tactics as taught by old-time writers on the sport—and a shot was taken at the ducks coming breast on to the gun. This shot with the right barrel brought down a duck, which fell dead some twenty-five yards away on my front. Then, with ample time to get in the second barrel, another duck was brought down—a highly pleasing right and left, as the birds were moving at great speed and height. The probability is that this style of shooting, the firing at oncoming fowl in this way, may be considered improper by some who strictly adhere to the canons of sport as laid down by early writers. The instruction I have in my mind was, in effect, not to fire at duck or goose until it had passed the gunner; but shooting at driven birds, if it does nothing else, enlarges one's views on many points in connection with gunnery, and teaches us the possibility of killing fowl coming end-on to the shooter.

Some ten minutes later a single duck, coming over at great height, was not detected until just as it was disappearing in the thickening gloom. Then the charge of shot sent after it had no apparent effect. Before the gun could be opened to insert another cartridge the rush of wings was heard, and, quickly looking up, I was just in time to

make out a little black lump moving rapidly on my right. There was time before the birds passed out of sight to get in the remaining barrel, but not to see the result of the shot. Listening intently, therefore, I was well pleased to hear the heavy "plock" of a falling duck away in the distance. Then, as the light was quickly failing, and as I had no dog to assist in recovering a wounded bird should the one last dropped proved to be winged, I lost no time in going in search of it. It was well that I did so, for, as it turned out, the duck was but winged, and had, with the customary cunning of its tribe, taken refuge under some long herbage overhanging the edge of a creek, from whence a close search of fully ten minutes was necessary to its discovery. Darkness shortly afterwards rendered shooting an impossibility, so, tramping across the wet and slippery saltings, I made the best of my way towards home. HENRY SHARP.

RIFLES FOR SMOKELESS OR BLACK POWDER.

(*Field*, Sept. 23, 1899; Vol. 94, p. 515.)

IN our issue of June 24 last we published the following notice:

"For several weeks past a controversy has been proceeding in our columns on the above subject, and, among other things, a real danger to sportsmen has been pointed out—viz., the intentional or inadvertent use of high-power cartridges loaded with nitro powder, in rifles built for use with black powder only.

"Black powder is like steam in this respect; what it is likely to do, and what it is capable of doing can be pretty accurately gauged beforehand, but, in spite of many assertions to the contrary, this cannot be said of any nitro powder at present known.

"In our trial of 12, 16, and 20-bores in 1896, the same velocity was obtained, after a few weeks of hot, dry weather, with 37grs. of powder as is usually obtained with 42grs. Not only is the powder affected by climatic influences, but the action of the fulminate in the caps is entirely altered.

"Nitro powder in rifle cartridges may be made to give greatly increased pressures by using bullets slightly larger in diameter, crimping the case tighter, or even by pushing the bullet into the case a little further than usual, thus reducing the air space.

"With a view to throwing some light on the question of the use of nitro powder in rifles built exclusively for black powder, we have commenced a series of trials with ·400, ·450, ·500, and ·577 bores, and purpose giving the velocities and pressures with standard loads."

Since that date we have made numerous trials with ·577, ·500, and ·450 bores.

We commence by giving the results of our trials with the largest bore, viz., ·577. The only nitro powder used in these trials was cordite, but, at the request of the manufacturers, we are quite willing to test any other kind of nitro powder, under as nearly as possible the same conditions. We commenced these trials in the belief that it would be an easy matter to prove to sportsmen the great danger they incur by using cartridges loaded with Cordite in rifles built for black powder only. But our trials so far as they have gone have not borne out our anticipations; on the contrary, for any given velocity, Cordite gives a lower chamber pressure than black powder. Loaded cartridges were subjected to a dry heat of 120° Fahr. for twelve hours, and fired whilst hot, but the pressures were actually lower than when the cartridges were fired at the normal temperature. We believe this phenomenon is due to the evaporation of a portion of the nitro-glycerine. Pushing the bullet further into the cartridge case, thus reducing the air space, is a very dangerous proceeding, as will be seen by the table below; if it is pushed in only one-eighth of an inch, the chamber pressure rises considerably.

TRIAL OF ·577-BORE CORDITE AND BLACK POWDER CARTRIDGES.

(Barometer, 29.84in.; thermometer—wet bulb, 61°; dry bulb, 65°.
Cordite, 76grs.; 560grs. nickel-coated solid bullet; wads—jute, wax, jute; 2⅝in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ⅛in.
1673	6·82	6·44	8·16
1670	6·94	6·30	8·00
1668	6·70	5·84	8·00
1666	6·94	5·67	7·90
1665	7·70	5·50	7·80
1663	6·82	5·34	7·50
Average 1667	Average 6·39	Average 5·85	Average 7·89

Cordite, 80grs.; 520grs. lead bullet, hollow point; wads—jute, wax, jute 2¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ⅛in.
1775	7·70	6·57	8·51
1765	8·08	6·44	8·44
1753	7·60	6·30	8·37
1753	8·00	6·15	8·30
1750	7·50	6·00	8·16
1735	7·50	5·84	8·08
Average 1755	Average 7·73	Average 6·21	Average 8·31

Black powder, 164grs.; 570grs. lead bullet, hollow point; wads, jute, cloth; 3in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.
1736	10·40
1734	10·73
1731	10·33
1728	10·00
1705	10·48
1705	10·26
Average 1723	Average 10·37

(*Field*, Sept. 30, 1898; Vol. 94, p. 569.)

·500-BORE.

Barometer, 29·85in.; thermometer—wet bulb, 60°; dry bulb, 66°.
Cordite, 64grs.; 480grs. nickel-coated solid bullet; wads—one jute, 3in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ⅛in.
1768	8·51	9·10	9·85
1766	8·79	9·00	9·60
1765	7·90	8·93	9·55
1754	8·65	8·72	9·40
1754	8·44	8·65	9·35
1750	8·30	8·58	9·10
Average 1759	Average 8·43	Average 8·83	Average 9·47

Cordite, 67grs.; 340grs. lead bullet, hollow point; wads—jute, wax, jute, 3in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ⅛in.
1967	8·30	8·44	9·30
1973	8·23	8·37	9·20
1970	8·37	8·30	9·20
1960	8·16	8·23	9·15
1955	8·51	8·16	8·86
1948	8·23	8·08	8·79
Average 1965	Average 8·30	Average 8·26	Average 9·08

Black powder, 135grs.; 440grs. lead bullet, hollow points; wads—jute, cloth, cloth; 3¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.
1765	10·00
1754	10·08
1753	10·33
1744	10·64
1741	10·97
1734	10·04
Average 1748	Average 10·51

(*Field*, Oct. 14, 1899; Vol. 94, p. 612.)

·450-BORE.

Barometer, 29·90in.; thermometer—wet bulb, 58°; dry bulb, 65°.
Cordite, 56grs.; 365grs. nickel-coated solid bullet; wads—jute, wax, jute 3¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ⅛in.
1899	10·12	9·50	10·20
1886	9·45	9·40	10·12
1883	9·40	9·35	10·04
1880	9·50	9·35	10·04
1873	9·90	9·20	9·65
1870	9·30	9·15	9·45
Average 1882	Average 9·61	Average 9·32	Average 9·91

Cordite, 59grs.; 270grs. lead bullet, hollow point; wads—jute, wax, jute; 3¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ¼in.
2054	8·72	8·65	10·00
2054	8·58	8·58	9·70
2050	8·65	8·51	9·65
2048	8·44	8·51	9·00
2029	8·51	8·06	8·93
2027	8·93	7·90	8·79
Average 2043	Average 8·64	Average 8·37	Average 9·34

Black powder, 110grs.; 325grs. lead bullet, hollow point; wads—jute, cloth, wax, jute; 3¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.
1770	9.85
1768	9·80
1765	10·40
1762	9·90
1760	10·16
1755	10·00
Average 1763	Average 10·02

(*Field*, Nov. 11, 1899; Vol. 94, p. 776.)

·400-BORE IN 2¾IN. CASE.

Barometer, 29·34in.; thermometer—wet bulb, 62°; dry bulb, 64°.
Cordite, 42grs.; 400grs. nickel-coated solid bullet; wads—jute, wax, jute; 2¾in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ¼in.
1694	11·52	11·06	15·50
1690	11·49	11·00	15·25
1685	11·46	10·04	15·00
1680	11·43	10·00	14·75
1674	11·40	9·55	14·75
1669	11·37	9·45	14·50
Average 1682	Average 11·44	Average 10·18	Average 14·96

Cordite, 33grs.; 230grs. lead bullet, hollow point; wads—jute, wax, jute; 2¾in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ¼in.
1629	5·17	6·15	5·50
1622	5·00	6·00	5·34
1620	4·80	5·84	5·34
1617	4·60	5·67	5·00
1608	4·40	5·50	4·80
1604	4·40	5·34	4·80
Average 1616	Average 4·73	Average 5·75	Average 5·13

Black, 82grs.; 275grs. lead bullet, hollow point; wads—jute, cloth, wax, jute; 2¾in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.
1678	10·88
1676	10·85
1676	10·85
1670	10·82
1666	10·79
1660	10·70
Average 1671	Average 10·81

(*Field*, Nov. 18, 1899; Vol. 94, p. 799.)

·400-BORE IN 3¼IN. CASE.

Barometer, 29·77; thermometer—wet bulb, 53°; dry bulb, 55°.
Cordite, 53grs.; 400grs. nickel-coated solid bullet; wads—one jute; 3¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ¼in.
1993	15·00	16·60	15·75
1960	14·75	16·40	15·75
1952	14·50	16·20	15·50
1940	14·50	16·00	15·25
1935	14·25	16·00	15·25
1935	14·00	15·50	15·00
Average 1952	Average 14·50	Average 16·12	Average 15·41

Cordite, 49grs.; 370grs. solid lead bullet; wads—one jute; 3¼in. Eley case and loading.

Muzzle velocity, ft. sec.	Pressures, tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet was pushed in ¼in.
1676	9·05	10·60	9·80
1663	8·93	9·90	9·75
1652	8·86	9·65	9·70
1648	8·79	9·50	9·65
1630	8·72	9·40	9·65
1604	8·65	9·35	9·60
Average 1644	Average 8·83	Average 9·73	Average 9·69

Black powder, 96grs.; 270grs. lead bullet, hollow point; wads—jute, cloth, wax, jute; 3¼in. Eley case and loading.

Muzzle velocity ft. sec.	Pressures, tons per sq. in.
1656	10·24
1664	10·20
1651	10·16
1647	10·12
1638	10·08
1630	10·08
Average 1649	Average 10·14

DEFINITIVE PROOF PRESSURES.

Rifles of ·577, ·500, ·450, and ·400 bores are proved with black powder and cylindrical lead bullets. The weights of powder and lead and the pressures are as follows:

Bore.	Powder.	Bullets.	Pressures, tons per sq. in.	Average.
·577	330grs.	800grs.	11·28, 9·05, 9·00, 8·93, 8·72,	8·65= 9·27
·500	300grs.	567grs.	13·75, 12·00, 11·97, 11·34, 11·06,	11·06=11·86
·450	240grs.	573grs.	11·00, 10·94, 10·20, 10·00,	9·75, 9·25=10·19
·400	170grs.	293grs.	12·00, 11·00, 10·94, 10·40,	10·36, 10·32=10·83

Field, Nov. 25, 1899; Vol. 94, 849.)

SUMMARY OF RECORDS.

As already stated, we commenced these trials in the belief that it would be an easy matter to prove to sportsmen the great danger they incurred by using cartridges loaded with Cordite in rifles built for Black powder only. Our trials have, however, conclusively proved that for any given velocity and weight of bullet Cordite gives lower chamber pressures than Black powder.

Subjecting the cartridges to moderately increased temperature does not appear to lead in the direction of danger, although, of course, no one would allow his cartridges to be exposed to the sun's rays in hot climates. Pushing the bullet into the case, and thus reducing the air space, generally results in a considerable increase of pressure. Had the cases been recrimped after pushing in the bullets, the pressures would have been still greater. We emphasise this fact as a warning to those sportsmen who load their own cartridges. The regularity in velocities and pressures given by Cordite will have been noticed by those who have carefully studied the particulars given in our previous issues.

There is only one other matter we need call attention to. It is the totally inadequate pressures given by the proof charges. In the ·577-bore the proof pressure is actually less than the service pressure. In the ·500, ·450, and ·400 bores the proof pressure is practically equal to the service pressure. This state of affairs is brought about by gunmakers continually striving to perfect their weapons, while the proof authorities prefer to remain quiescent.

·577-BORE.

	Muzzle Velocity Ft.sec.	Pressures. Tons per sq. in.	Pressures after exposure to 120° Fahr. for twelve hours.	Pressures after the bullet had been pushed in ¼in.	Definitive Proof Pressures.
Cordite 76grs., 560grs. nickel-coated solid bullet.....	1667	6·99	5·85	7·89	—
Cordite 80grs., 520grs. lead bullet, hollow point	1755	7·73	6·21	8·31	9·27
Black powder 164grs, 570grs. lead bullet, hollow point..	1723	10·37	—	—	—

All the pressures in the trials as given above were taken at a distance of one inch from the breech of the rifle.

·500-BORE.

Cordite 64grs., 480grs. nickel-coated solid bullet.....	1759	8·43	·88	9·47	—
Cordite 67grs., 340grs. lead bullet, hollow point	1965	8·30	·26	·08	11·86
Black powder 135grs., 440grs. lead bullet, hollow point..	1748	10·51	—	—	—

·450-BORE.

Cordite 56grs., 365grs. nickel-coated solid bullet.....	1882	9·61		9·91	—
Cordite 59grs., 270grs. lead bullet, hollow point	2043	8·64	8·37	9·34	10·19
Black powder 110grs., 325grs. lead bullet, hollow point..	1763	10·02	—	—	—

·400-BORE.

Cordite 42grs., 400grs. nickel-coated solid bullet.....	1682	11·44	10·18	14·96	—
Cordite 38grs., 230grs. lead bullet, hollow point	1616	4·73	5·75	5·13	10·83
Black powder 82grs., 275grs. lead bullet, hollow point..	1671	10·81	—	—	—
Cordite 53grs., 400grs. nickel-coated solid bullet.....	1952	14·50	16·12	15·41	—
Cordite 49grs., 370grs. solid lead bullet ...	1644	8·83	·73	9·69	—
Black powder 96grs., 270grs. lead bullet, hollow point..		0·14	—	—	—

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